STATUS OF MINERAL RESOURCE INFORMATION FOR THE ANNETTE ISLANDS RESERVE, SOUTHEASTERN ALASKA

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SUMMARY AND CONCLUSIONS

Previous field studies of the Annette Islands Reserve, Alaska, indicate that parts of the Reserve are well mineralized, specifically areas on the Sylburn Peninsula and part of the Crab Bay area. Lead, zinc, barite, silver, and gold are the main potential commodities. There is a possibility of lead-zinc-silver bearing barite deposits in excess of 1,000,000 tons on the Sylburn Peninsula. Other areas with potential for economic minerals include the Yellow Hill area, which may host an iron ore deposit and should be investigated for platinum, and southeastern Annette Island, where unmapped correlative units to the mineralized limestone and dolomite in the Crab Bay area may occur. With the possible exception of uranium, no mineral fuels exist on the islands.

The Reserve is favorably located for development, and Metlakatla has a labor force which includes men familiar with heavy equipment. One 3,000 KW hydroelectric site has been developed and the potential for others exists.

INTRODUCTION

Annette Island was set aside in 1891 as a reservation for the former British Columbia natives brought to Alaska by Father William Duncan. The reservation is unusual in that it was extended in 1916 to 3,000 feet from the shore line and thus includes smaller islands--and is properly called "The Annette Islands Reserve." Prior to the withdrawal of this land for a reservation, the existence of mineral potential on Annette was established by prospecting activity. Prospecting continued sporadically after withdrawal, due partly to an uncertainty of the land status of the Reserve. As it gradually became known that the island was closed to public law mining entry, prospecting nearly ceased. Periodically, however, interest was expressed in mineral development and some prospecting was done with approval of the Metlakatla villagers. It was not until 1963 that a formal ruling of the Interior Department Solicitor (Memorandum M-36658) established that prospecting could be done and mining rights acquired under the Indian Mineral Leasing Act of 1938 (52 Stat. 347, 25 U.S.C., Sec. 396 a-f).

This report has been compiled for the U.S. Bureau of Indian Affairs (BIA) by personnel of the U.S. Bureau of Mines (USBM) and U.S. Geological Survey (USGS) under an interagency agreement to compile and summarize available information on the geology, minerals, energy resources, and potential for economic mineral resource development of Indian lands. Sources of information include published and unpublished reports. No field work was done.

Acknowledgments

This report is a compilation based mainly on both published and unpublished investigations by H. C. Berg of the USGS and by C. C. Hawley and Associates of Anchorage, Alaska; the Hawley firm's work was done under contract to BIA. Original figures and tables were provided by C. C. Hawley. Mayor W. D. Leask of the Metlakatla Indian Community provided a copy of the report on the drilling of the Sylburn Peninsula barite deposit.

Geography

Annette Island is in southernmost southeast Alaska, about six miles south of Ketchikan (Figure 1). The Reserve extends 3, 000 feet outward from a main island mass of about 133 square miles, and includes Ham Island, Hemlock Island and several smaller islands.

The Annette climate is typically maritime. The large surrounding mass of water moderates the temperatures. The July maximum and minimum average temperatures are respectively 54º and 50º F; in January they are 42º and 28º respectively. Heavy precipitation is also characteristic. The annual precipitation at the Annette airport is about 155 inches, and the amount of precipitation increases with altitude. Snowfall is 100 inches or more on the mountain tops.

Access to Annette Island is by aircraft and boat. The Alaska Marine Highway system operates M/V Chilkat between Ketchikan and Metlakatla twice a day on Monday, Tuesday, Thursday and Saturday. Most heavy freight comes to the village via ferry. In addition there is a good small boat harbor and wharfage at the cannery. There is also a lumber mill with a dock for large log freighters. An 8,000 foot hard-surfaced runway suitable for all classes of aircraft is six miles south of Metlakatla on the Metlakatla Peninsula. This airfield serviced the Ketchikan area until the field on Gravina Island was built. Numerous air taxi operators service the area with wheel, float or amphibious planes. In addition to Tamgas Harbor and Metlakatla Village at least ten of the larger lakes, plus Crab Bay, Kwain Bay, Annette Bay and Sylburn Harbor, have reasonable float plane air access. Some exposed parts of the coastline are suitable for float plane operations in good weather.

About 30 miles of road have been built and maintained on the Metlakatla Peninsula. Although not as well developed, the Annette Island mainland is accessible by water, and has a ten-mile logging road system which is planned to extend from a loading ramp on the south side of Sylburn Peninsula to Annette Bay on the northern part of the island.

Except for temporary residency at logging camps on the north part of the island, the entire population lives on Metlakatla Peninsula. The native population of 1,100 people lives at Metlakatla. A Coast Guard Station occupied Rolland Village on Tamgas Bay in 1975, but this station has since moved to Sitka.

The primary Metlakatla industry is fishing (mainly salmon, but also including halibut, red snapper, and other species). A well maintained village fish processing facility including freezer and cannery is of major importance to the village economy. A BIA subsidized construction industry builds and maintains roads and also supports the only present mineral extraction industry on the island--quarrying and crushing of dunite from Yellow Hill for road material. As a result of this industry, local men have been trained in operation and maintenance of heavy equipment.

In recent years, hemlock logging has taken place between Sylburn Harbor and Annette Bay, and a lumber mill is located at Metlakatla. This industry tends to be very sensitive to market fluctuations and activity has been intermittent.

Physiography

Topographically, Annette Island is divided into the relatively flat Metlakatla Peninsula and a moderately rugged and glacially sculptured mainland. The Metlakatla Peninsula consists of almost 21 square miles of flat muskeg and scrubby tree covered land. The peninsula, with an average elevation of about100 feet, is dotted with numerous small ponds. A highly resistant dunite body underlies the Yellow Hill area on the northern part of the peninsula and has a maximum elevation of 540 feet. In contrast, the Annette mainland consists of rounded mountains and U-shaped valleys. The highest peak, Tamgas Mountain, has an elevation of 3,591 feet, and numerous peaks exceed 2,000 feet. The valley walls rise precipitously from glacially scoured valley bottoms. Purple Lake, Tamgas Lake, Trout, Melanson and several smaller lakes occupy generally east-west scenic valleys reminiscent of the California Sierra Nevada. Except on the highest peaks and certain rock units, the mainland terrain is covered with forests, some of commercial value.

Prospecting Activity

Examination of records at Ketchikan show that about 50 claims were staked on the Annette Islands Reserve between 1900-1937, with at least 37 claims in the Crab Bay area on the east side of the island, 10 claims on Ham Island, and 2 claims east of lower Todd Lake. Prospectors of record included H. W. Edwards, John Hanson, W. A. Pries, J. F. Gheshl, R. S. Dodge, A. C. Kriller, Frank Goff, Carl La Vanderpool, Finzell, Radenbough, Florence Morlock, F. H. Bold and B. R. Libe. Local residents also prospected on the island. John Smith of Metlakatla recalls helping his father prospect--including trenching activity--in the Todd Lakes area. Other residents found mineralized material while on hunting trips throughout the island.

Actual mining must have been very minor. With the exception of a short adit driven in the rhyolite above Crab Bay, the only reported evidences of prospecting are trenches and shallow shafts in the lower Todd Lake area and on Ham Island. Residents also mention a lead mine operated by Japanese on Sylburn Peninsula–which is partly documented by the local name of Japan Bay, a harbor in the Sylburn Peninsula area.

Most of the early prospecting efforts were apparently made without knowledge of the reserve status on the island, and there was little prospecting activity between about 1940 and 1960. Since 1960, there have been valid prospecting efforts based on permits issued at Metlakatla. In 1969-70, Humble Oil (now Exxon) obtained a non-exclusive permit to prospect. Their exploration resulted in an important amount of information that was made available to the Metlakatlans, and these data have been used in compiling this report. Also included are the results of drilling on a barite deposit on the Sylburn Peninsula. This work was accomplished in 1976 by Alcom Exploration for the Metlakatla Indian Community.

Previous Geologic Studies

The only extensive geologic work done on Annette Island was conducted by H. C. Berg who mapped the island for the U.S. Geological Survey in 1966, 1967 and 1968 (Berg, 1972). Subsequently (1969-1970) Berg also mapped Gravina Island, northwest of Annette (Berg, 1973). Many of the rock units on Annette correlate with units on Gravina. In 1975-77, the USGS conducted a mineral appraisal of the Ketchikan Prince Rupert (including Annette Island) area under its Alaska Mineral Resource Assessment Program (AMRAP) (Berg and others, 1978; Berg, 1980). Since 1978, geological and mineral resource field studies by the USGS in the Annette Island area have continued as part of its current investigation of regional metallogenesis and resource assessment of southeastern Alaska.

The BIA funded geologic and prospecting efforts on the Reserve by C. C. Hawley and Associates in 1975, 1978 and 1980. The 1975 study included a two month reconnaissance of the Reserve that involved geologic prospecting and soil and stream sediment sampling. Additional studies were made on the Sylburn Peninsula in 1978 and 1980 of a barite, lead and zinc deposit. The 1980 study was in progress at the time this report was being compiled and is therefore not included here.

Earlier work of importance includes that of Taylor (1967) on Yellow Hill. Magnetometer studies made during Hawley's investigation (1975, p. 1-7) suggest that Taylor's work more correctly depicts the Yellow Hill ultramafic than does Berg's. A. H. Koschmann and H. A. Coombs of the USGS appraised the mineral potential of the island in 1934. This work is unpublished; interestingly, it stresses the stratigraphic nature of ore controls on the island, and suggests that certain volcanic-sedimentary units are worthy of more prospecting.

The earliest USGS studies were by Brooks (1902) and F. E. and C. W. Wright (1908).

GENERAL GEOLOGY

Annette Island is dominated by the Annette pluton, a trondhjemite (sodic granitic) pluton of Silurian or older age centered on the Annette Island mainland (Figure 2). The pluton was intruded into older greenschist-to-amphibolite-grade metamorphosed rocks. Metamorphosed Devonian and Silurian marine strata that overlie the pluton may include extrusive phases of the Annette pluton. No record exists of Mississippian-Permian sedimentation but volcanism and marine sedimentation occurred during parts of the Triassic and Jurassic or Cretaceous periods. During Cretaceous time there were further intrusions--both of ultramafic and granitic rocks.

With the possible exception of a fault between the Annette "mainland" and the Metlakatla Peninsula, faulting has not caused major rock redistribution. The main rock pattern is the Annette pluton flanked on the south and west by mostly older rocks, and the north and east by successively younger rocks. Local structures complicate this simple picture, especially on the Sylburn Peninsula where different rock units are juxtaposed by numerous faults and folds.

The geologic map in the report (Figure 2) is on a larger scale than the original USGS map (Berg, 1972). The enlargement reflects no greater accuracy, but was more convenient for plotting sample locations.

Correlation of Rock Units

Mineralization is apparently characteristic of certain geologic intervals correlating specifically with (1) some phases of the Annette pluton, (2) the Triassic rhyolite and intertonguing volcaniclastic and sedimentary rocks, and (3) the Cretaceous or Jurassic intermediate volcanic and fragmental rocks. Since stratigraphic control apparently exists, correlation of units is important economically.

Hawley and Associates (1975, p. 2-3), compiled a correlation chart based on stratigraphic information available to them at the time of their investigation. Since then, evidence based on fossil collections (Berg, 1980, p. 10-12) shows that the potentially most valuable stratabound mineral deposits known are hosted by Triassic, not Paleozoic, felsic (rhyolite) volcanic, volcaniclastic, and sedimentary rocks. The explanations on Figure 2 and Figure 3 incorporate these recent stratigraphic data. They also reflect the results of recent isotope age determinations on some of the other rock units (Smith and Diggles, 1980).

In a few places the contacts mapped by Berg have been revised by Hawley and Associates (1975). On the east side of the island north of Crab Bay, Hawley and Associates (1975, p. 2-2) moved the basal contact of the felsic volcanic and volcaniclastic unit (Trv, Trc) several hundred feet west into the area mapped by Berg as Annette pluton. The thinly layered rhyolite tuff is underlain by a coarse crystal tuff which is difficult to distinguish from the trondhjemite. The detailed nature of this problem was beyond the scope of their investigation, but it could have economic significance because the sheared crystal tuff(?) locally has disseminated chalcopyrite. Phases of the Yellow Hill ultramafic body also need further clarification. Contacts suggested by magnetometer are shown in detail on Figure 3.

Description of Rock Units

The dominant rock units on Annette Island are a very light colored, generally massive trondhjemite (sometimes also called soda granite) and correlative darker-hued quartz diorite, and light gray rhyolite and dark-colored layered rocks of both younger and older age than the trondhjemite. The dunite of Yellow Hill is a characteristic dense greenish-black rock which weathers to ochre-yellow color. The rhyolite and light colored, generally massive, limestone units are easily distinguished, as is a pillow basalt of Triassic age.

All the rocks in the Annette Island area have undergone one or more episodes of metamorphism during which they recrystallized and were more or less foliated, depending on the metamorphic susceptibility of the original rock. In the lithologic descriptions that follow, however, nonmetamorphic rock names such as limestone, graywacke, diorite, etc., are occasionally used to avoid undue repetition of such cumbersome qualifying terms as "recrystallized","altered", "meta-", etc.

Silurian or Older Rocks

Greenstone and Greenschist (Sg)--This unit consists of greenschist-to-amphibolite facies metamorphic rocks, chiefly greenstone and greenschist, together with subordinate amounts of phyllite, limestone, graywacke, siltstone, and quartzite. The assemblage was derived mainly from sodic and calcalkaline felsic, intermediate, and mafic igneous rocks and from relatively minor interbedded marine sedimentary rocks. The unit is intruded by the Silurian or older Annette pluton, and thus is also assigned an age of Silurian or older. The thickness of the unit is unknown, but its large outcrop area suggests that it is at least several hundred and perhaps several thousand meters thick.

Annette Pluton (Slg, Sgg, Spbx)--The Annette pluton is a composite trondhjemitic stock that makes up about two-thirds of Annette Island. The pluton is crudely and incompletely zoned and grades from a core of leucotrondhjemite and minor leucocratic granite, quartz monzonite, and granodiorite (Slg), to bordering masses of trondhjemite and leucocratic quartz diorite and minor diorite (Sgg).

A minimum age of about 424 m.y. (Silurian) has been determined for hornblende in the leucocratic quartz diorite.

The pluton is moderately to strongly deformed and in many places has a border zone up to several hundred feet wide of schist, gneiss, and breccia. At least some of the breccia is probably of protoclastic (late magmatic) origin, and one area of such rocks (Spbx) is shown on Figure 2.

Central Metlakatla Pluton (Smg)--The Central Metlakatla pluton is a foliated recrystallized leucocratic quartz diorite stock that underlies the central part of Metlakatla Peninsula. In part, the foliation may be due to flow near the margins of the pluton during emplacement; most, however, is due to subsequent metamorphism, and some to still later relatively local cataclastic deformation.

The age of the Central Metlakatla pluton is inferred to be Silurian or older because 1) it is similar to the trondhjemite and leucocratic quartz diorite phases of the Annette pluton, with which it may be coeval and 2) K/Ar dating indicates a minimum age of about 306 m.y. (Smith and Diggles, 1980).

Devonian and Silurian Rocks

Undivided Volcanic and Sedimentary Rocks (DSvs)--This unit comprises interbedded pyritic phyllite, phyllitic silty limestone and calcareous siltstone, feldspathic to arkosic sandstone, grit, and conglomerate, dolomitic limestone and arenite, and phyllitic calcarenite and limestone breccia. It also includes phyllite and schist derived from: 1) sedimentary rocks ranging from feldspathic to arkosic siltstone and sandstone to cobble conglomerate containing abundant clasts of leucotrondhjemite; 2) silty to sandy, probably tuffaceous, dolomite; 3) felsic tuff(?); and 4) felsic to intermediate igneous rocks. Locally the phyllite and limestone carry poorly preserved Devonian and Upper Silurian fossils. The base of the unit is not exposed; its thickness is unknown but it probably is at least several hundred meters thick.

Mesozoic or Paleozoic Rocks

South Metlakatla Pluton (MzPzq)--The South Metlakatla pluton is a stocklike intrusion that crops out at the south end of Metlakatla Peninsula. The pluton, which locally contains large inclusions of metamorphosed bedded rocks, consists of greenish-gray medium-grained recrystallized quartz diorite and diorite. The relative abundance of each rock type has not been determined, but the diorite seems to increase in abundance southward, toward Point Davison, suggesting that the pluton may be crudely zoned.

Throughout the pluton, but especially near the margins, the intrusive rock is more or less abundantly mixed with amphibolite facies metamorphosed bedded rocks, forming diffusely bounded bodies of migmatite. Because of this, the distinction between plutonic and country rocks is largely indefinite, and on Figure 2, the contact is drawn wherever the volume of plutonic rocks is greater than that of metamorphosed bedded rocks.

A K/Ar date on metamorphic hornblende from the Central Metlakatla pluton gave an age of about 205 m.y. (Smith and Diggles, 1980), implying a minimum Triassic age for the unit. In this report, the pluton is assigned an age of Mesozoic or Paleozoic.

Triassic Rocks

In this report, Triassic bedded rocks on Annette Island comprise four conformable and intertonguing map units: a discontinuous basal unit of rhyolitic ash flow tuff and breccia (Trc); banded metarhyolite (Trv); massive limestone and dolomite (Trl); and an uppermost sequence of sedimentary and basaltic volcanic rocks (Trvs). The Triassic age of these four units is established on the basis of Upper Triassic fossils in the massive limestone and dolomite and is the overlying sedimentary rocks, and on their stratigraphic relations.

Felsic Volcanic Rocks (Trc, Trv)--These rocks comprise two map units: a basal unit of rhyolitic ash flow tuff and breccia (Trc), and an upper unit of banded metarhyolite (Trv) that locally grades downwards and laterally into the tuff and breccia unit. In this report, the basal unit is mapped only in the Kwain Bay-Crab Bay area (Figure 4). The sequence is economically significant because it hosts stratabound volcanogenic mineral deposits containing Pb, Zn, Ag, Au and barite.

The basal unit (Trc) consists of massive to phyllitic fragmental rocks that have two principal occurrences: as lenses and discontinuous beds conformably underlying the banded metarhyolite; and as lenses and wedges that locally intertongue with calcareous tuff and tuffaceous limestone and dolomite. In the Kwain Bay-Crab Bay area, the unit consists of an elongate lens of quartz-sericite-albite phyllite and schist containing prominent relict clasts of trondhjemite, quartz diorite, and sparse greenstone. This rock, which depositionally overlies the Annette pluton and older rocks and grades upward into banded metarhyolite is interpreted as a recrystallized subaerial ash-flow that accumulated abundant surficial debris as the flow advanced over exposed, predominantly granitic terrane. Elsewhere on Annette Island, the unit includes massive to phyllitic, chaotic to well-bedded, brown-, green-, and red-weathering breccia, grit, and conglomerate containing clasts up to 60 cm long of leucocratic granitic rocks, fragmental quartz and plagioclase, and minor metarhyolite, limestone, and foliated fine-grained detrital rocks. In the massive and well-bedded varieties, the matrix is brown-weathering dolomite containing minor sericite and hematite and thin seams of K-feldspar; in the phyllitic varieties the matrix is mainly sericite, microgranular quartz and albite, hematite, and calcite. The estimated maximum thickness of the unit is150 meters.

The banded metarhyolite unit (Trv) probably originated mainly as subaerial ash flows and tuff and subordinately as marine tuff and tuffaceous sediments. A small part of the unit probably was extruded as domes and short lava flows. In the Kwain Bay-Crab Bay area, the metarhyolite consists chiefly of light-gray, light-green, and light-brown phyllite and platy, nonfissile schist containing the greenschist-facies regional metamorphic mineral assemblage quartz, muscovite, K-feldspar, albite, calcite, and dolomite. Despite the recrystallization, relict features such as flow lamination and spherulitic, vitroclastic, fragmental, and porphyroaphanitic textures locally are well preserved. On Sylburn Peninsula the unit consists of massive to thinly laminated, diversely colored aphanite, locally with prominent spherulitic texture, and subordinate phyllite and phyllitic aphanite. At the western tip of Sylburn Peninsula massive light-gray aphanitic metarhyolite is overlain by about 15 meters of recrystallized marine rhyolite tuff and rhyolitic ash- and lapilli-rich dolomite. The estimated maximum thickness of the unit is about 200 meters.

Limestone and Dolomite (Trl)--This unit consists of massive, dark bluish-gray, very finely crystalline limestone distinguished by such weathering features as solution pits and valleys, caverns, and underground drainage. Most of the limestone is massive and calcitic, but locally it is moderately to thickly bedded and, in a few places, dolomitic. In the Crab Bay area, this unit contains galena, sphalerite, and other sulfide minerals in several places. Samples of limestone collected by the USGS in 1979 from this unit at Sink Lake and from coastal outcrops about 1.6 km south of the mouth of Kwain Bay (Figure 2 and Figure 4) yielded microfossils (conodonts) of Late Triassic age (Berg, 1980, p.10-12). The maximum thickness of the unit is about 70 meters.

Sedimentary Rocks and Basaltic Volcanic Rocks (Trvs)--The sedimentary rocks in this unit consist of dark-brown to sooty-gray, interbedded, carbonaceous limestone, calcareous siltstone and mudstone, subordinate thin- to medium-bedded light-gray very fine grained limestone, and minor pebbly limestone and carbonate-cemented granule to cobble conglomerate. The beds characteristically are intricately folded, complexly lineated, and phyllitic and contain the greenschist-facies regional metamorphic mineral assemblage sericite, quartz, albite, chlorite, calcite, and clinozoisite. The darker-hued rocks contain abundant graphite and locally are strikingly rich in well-crystallized pyrite. The carbonaceous beds and the limestone locally contain well-preserved Upper Triassic fossils. The estimated maximum thickness of the member is 100 meters.

The volcanic rocks in this unit consist of basaltic pillow flows, breccia, and tuff that grade laterally into massive carbonate cemented basalt-clast breccia and calcareous basaltic tuff. The flows are characterized by deformed pillows up to a meter in diameter and a matrix of calcitic limestone and altered volcanic material. The pillows are very fine grained, dark greenish gray, and consist of a relict intersertal-felty aggregate of secondary minerals, plus pinhead-size calcite amygdules. The maximum thickness of the unit is probably about 170 meters.

Cretaceous or Jurassic Rocks

Intermediate Volcanic Rocks and Sedimentary Rocks (KJvs)--This sequence consists of two main rock types: a basal sedimentary unit of phyllite, slate, graywacke, and conglomerate; and an upper volcanic unit of andesitic to basaltic metatuff and agglomerate that grades downward and laterally into the sedimentary unit. The Cretaceous or Jurassic age of the sequence is based on Upper Jurassic and mid-Cretaceous fossils collected from correlative rocks on Gravina Island and elsewhere in southeastern Alaska (Berg, 1980, p. 23). Maximum thickness of the sequence may be about 800 meters.

The most abundant rock types in the sedimentary unit are lineated dark-gray slate and silvery green and gray phyllite; less abundant, but locally prominent, are slaty to phyllitic graywacke, calcareous siltstone and other fine-grained detrital rocks, and conglomerate. The conglomerate consists of moderately to strongly deformed, angular to subrounded clasts up to a meter long in a matrix of dark-gray phyllite and phyllitic grit. The clasts include porphyritic and aphanitic intermediate igneous rocks derived from the metavolcanic unit, dark-gray phyllitic limestone and fine-grained sedimentary rocks, minor felsic igneous rocks, and rare mafic igneous rocks.

The volcanic unit consists of light-greenish- and brownish-gray recrystallized andesitic to basaltic volcanic and volcaniclastic rocks and subordinate metasedimentary rocks. Some of the metavolcanics are massive or only crudely foliated, but most are phyllitic. The volcanic rocks display relict porphyritic, fragmental, amygdaloidal, and aphanitic textures. The prevailing rock type is foliated agglomerate consisting of porphyritic clasts in a porphyritic to aphanitic base. Relict phenocrysts consist of altered plagioclase crystals up to a centimeter long and less abundant altered ferromagnesian crystals of comparable size. Most of the ferromagnesian minerals apparently are hornblende or its alteration products; relict clinopyroxene phenocrysts have been recognized only in a small part of the unit. Varieties containing only plagioclase phenocrysts are common, but most of the unit contains at least some ferromagnesian phenocrysts; locally they are strikingly abundant and the plagioclase is absent. Quartz is rarely visible in hand specimens, but under the microscope can be detected in some specimens in amounts up to about 10 percent.

Diorite and Quartz Diorite (KJd)--This texturally diverse pluton consists of greenish-gray, fine- to medium-grained diorite and minor quartz diorite. It is moderately foliated and strongly hydrothermally altered, but relict granitoid, porphyritic, and ophitic textures generally are preserved. The granitoid and porphyritic varieties predominate and probably occur in about equal amounts; field relations indicate that they probably are transitional and that the porphyritic parts of the pluton generally are more abundant near its margin.

The pluton intrudes Cretaceous or Jurassic bedded rocks, but except for some local baking of the beds along the southwest shoreline of Annette

Bay, the contact generally is not marked by an intense thermal aureole. The outcrop pattern and structural relations indicate that the pluton is a northeastward-dipping (or plunging) body, possibly with an elongate plug like or crudely tabular shape.

The porphyritic parts of the pluton, which probably signify relatively rapid chilling at its margin, are texturally, compositionally, and chemically similar to parts of the adjoining Cretaceous or Jurassic metavolcanic country rocks. These similarities, plus their close spatial relation and lack of significant thermal effects at their contact, suggest that the pluton and the metavolcanic rocks may be cogenetic, the pluton being a hypabyssal variant of the intermediate volcanic rocks. On this basis, the pluton is assigned a Cretaceous or Jurassic age.

Cretaceous Rocks

Dunite and Pyroxenite (Kdp)--Distinctive ultramafic plutonic rocks underlie Yellow Hill and a small nearby area on the Metlakatla Peninsula. The pluton at Yellow Hill consists of a main body of ochre-weathering, dark greenish-black, partly serpentinized dunite containing traces of chromite, and of subordinate hornblende-clinopyroxenite that locally is rich in magnetite. A magnetic survey by Hawley and Associates (1975) indicates that the main zone of magnetite-bearing pyroxenite forms the western and southern margins of the pluton, but dikes or layers of pyroxenite also occur in the dunite. The dunite-pyroxenite body is in contact with several varieties of metamorphic country rocks but in none of them could thermal metamorphism associated with hot intrusion of the ultramafic be detected. Taylor (1967, p. 97-121) classified the body as a zoned ultramafic intrusive complex, but most of the present contacts appear to be faults.

The age of the ultramafic body at Yellow Hill is inferred to be Cretaceous on the basis of correlation with zoned ultramafic rocks elsewhere in the Ketchikan-Prince Rupert area that have yielded K/Ar ages of about 100 m.y. (Smith and Diggles, 1980).

Granodiorite (Kg)--Spire Island and nearby reefs about a kilometer from the north coast of Annette Island are underlain by massive to gneissic brownish-gray medium-grained granodiorite and quartz diorite. Muscovite from this pluton, which is interpreted as a small stock or plug, has yielded a K/Ar age of about 89 m.y. (Smith and Diggles, 1980).

ECONOMIC GEOLOGY

Geochemical Surveys

Stream sediment samples were collected across most of the island, (with the exception of the flatter terrain of the Metlakatla Peninsula where stream drainages are poorly developed), by Hawley and Associates (1975) and by Humble Oil (now Exxon) in 1969-70. Detailed soil sampling was done in mineralized areas including several prospects in the Crab Bay and Sylburn Peninsula regions by Hawley and Associates (1975, 1978).

Stream Sediment Sampling Programs

The results of all stream sediment analyses are given in the Appendix to this report, sample numbers are keyed to a map (Figure 5).

Analyses were made by atomic absorption. Anomalous levels of Cu, Pb, Zn, Mo and Ag were determined by C. C. Hawley and Associates (1975, p. 3-2) from histograms and cumulative frequency diagrams. The 1975 collection represents280 samples and there are 210 in the Humble series. Statistical results are summarized in Table 1.

TABLE 1

Summary of Statistical Results, Stream Sediment Analyses

	Mean	Mean plus 2 Standard Deviations	Cumulative Population Break	Anomalous Level Definition	% of Anomalous Samples
			ppm		
1975 Samples					
Copper	12	45	50	50	4%
Lead	16	50	50	50	3%
Zinc	51	160	160,275	200	4%
Humble Samples					
Copper	21	58	40	70	4%
Lead	25	67	50	80	4%
Zinc	110	276	75,240	300	3%
All Stream Sediment Samples					
Copper	18	72			
Lead	22	62			
Zinc	84	250			

The Humble Oil samples are heavily weighted toward the northern part of the Annette pluton and appear to comprise a distinct population. This portion of the pluton is composed mostly of quartz diorite and trondhjemite. The normal trondhjemite has relatively higher copper, lead and zinc backgrounds than the rest of the island rocks. It is believed that these higher background values reflect widespread but generally weak metallization in this unit.

Analysis for molybdenum was requested in the 1975 study because of the highly differentiated nature of the light-colored trondhjemite which shows widespread quartz veinlet systems. The results suggest that the intrusive shows little tendency towards molybdenum enrichment. Based mainly on comparison with other regions, any level of molybdenum over a few ppm is believed anomalous.

Soil Sampling Programs

Soil sampling was conducted in two regions of the Annette Islands Reserve, the Crab Bay area (Hawley and Associates, 1975) and the Sylburn Peninsula (Hawley and Associates, 1975, 1978).

Based mainly on old reports, it was believed that the felsic metavolcanics near Crab Bay were widely mineralized; to check this possibility, Hawley and Associates (1975, p. 3-6) made reconnaissance soil lines across the unit at several places (Figure 4).

The detailed results of the Crab Bay surveys are given in later sections of this report, but in general the results indicate very low quantities of copper, lead, zinc, and molybdenum. However, gold was determined in anomalous amounts on several lines.

The soils were collected with a 2-inch auger from approximately the "C" horizon; at least on the felsic metavolcanic unit, these soils are thin and nearly residual in character. They support only grass and shrub vegetation.

The analytical threshold for gold varied with size of the sample. With at least 10 grams, the lower limit was 0.02 ppm, increasing in increments with smaller splits available. In general gold determined at any level was believed anomalous, but samples in excess of 0.10 ppm strongly anomalous.

Soil sampling was also used in 1975, to try to extend mapped visible mineralization in the Sylburn Harbor area. As at Crab Bay auger sampling was used. The Sylburn soils are thin generally, but vegetation is thick and it is sometimes difficult to collect mineral-rich soils. In the Sylburn area, soils were analyzed for silver, gold, barium, copper, lead and zinc.

In 1978, a soil grid was emplaced along N-S brushed and surveyed lines at1000 foot intervals across the Sylburn Peninsula (Hawley and Associates, 1978). Twenty-one thousand feet of line were established and 215 soil samples collected. Soils were sampled as deeply as possible in a section penetrated by a 1½-inch, 3-foot hand-held soil auger. In most cases this was sufficient to sample the "C" horizon. The soil samples were screened and analyzed for barium, lead, zinc and silver; most were analyzed for copper. In part, the values from this survey correspond to mineralization previously known, as at Berg's locality 18; in part they indicate new areas of mineralization.

In general, it was found that high barium in soils correspond to areas of metarhyolite, while lead, zinc and silver anomalies are partly coincident with metarhyolite, but are generally associated with limy sedimentary rocks.

Magnetometer Survey

A magnetometer survey was made of the Yellow Hill ultramafic body by Hawley and Associates (1975). The main purpose of this survey was to search for more magnetite-rich units of the ultramafic body, which might have more economic potential than the normal dunite.

The survey was of reconnaissance character; N-S and E-W lines were run across the intrusive mainly to define the contact, especially on the west side.

A very strong magnetic trend was discovered on the west side of Yellow Hill (Figure 3). The anomalous magnetic zone is about one mile long and three hundred to one thousand feet wide. The magnetic signature is quite distinct and very little rock is exposed along the anomalous area. It is believed that the anomaly probably represents a buried unit such as hornblende pyroxenite with a relatively high magnetite content.

The anomalous values detected are up to 10,000 milligammas in strength. Broad anomalous sections are composed of several smaller anomalies which could represent smaller intrusive zones or phases within the large magnetic complex. Units mapped by Berg (1972) as clinopyroxenite do not show up, or do so with anomalies on the order of several hundred milligammas. It is likely therefore that the magnetic belt is composed of a rock unit which is not exposed, except possibly in the small areas mapped by Taylor (1967).

The magnetite content of other Alaska type hornblende-pyroxenite seems to be a relatively constant 10-15 percent. The magnetite content of Yellow Hill dunite is at most several percent, so the high magnetic values west of Yellow Hill could result from a magnetite-hornblende pyroxenite. The contacts between the magnetic zone and surrounding rock can be well defined by the magnetic data. However, the contact between the dunite and surrounding granite or metamorphic layered rocks is not so distinct. Perhaps more detailed magnetic surveys, especially to the east and south of Yellow Hill, could define these dunite boundaries. Drilling or trenching would be necessary to fully define the Yellow Hill intrusive phases and magnetic area.

Metallic Mineral Resources

Two main mineralized areas termed the Sylburn Peninsula and Crab Bay areas, can be identified with present information. Other small areas are mineralized, and a few other areas cannot yet be eliminated from prospecting effort, such as the Yellow Hill ultramafic body, where the potential for an iron ore deposit with possible platinum credits should be investigated. It does not appear that the main body of the Annette pluton or the Paleozoic units are significantly mineralized, although the margin of the pluton locally is weakly mineralized in porphyry fashion. The Sylburn Peninsula area has two occurrences which appear to be valid prospects for barite-lead-zinc-silver (?) mineral deposits.

Sylburn Peninsula Area

The mineralized terrane is a 1.5 to 3 square mile area (Figure 2) about 3 miles due north of Metlakatla. Hemlock Island is a southern satellite of the Peninsula. The area is complexly faulted and folded on a small scale. Because of heavy vegetation, the geology has mostly been determined from shore line exposures and from rock fragments found in soil materials along the brushed and surveyed lines during the 1978 study by Hawley and Associates. The peninsula consists of Silurian or older greenstone and trondhjemite, and felsic volcanic rocks, limestone, sedimentary rocks, and basalt of Triassic age. The distribution of lithologic units and the structure shown on Berg's 1972 map were revised somewhat as a result of the 1978 study.

Mineral occurrences visible on the periphery of the Peninsula includes phalerite-chalcopyrite-quartz veinlets and manganiferous limestone (?) near the log ramp area on the southeast side of the Peninsula, and barite-sulfide shows at four places on the periphery--these localities were referred to on Berg's map (1972) as mineral occurrences numbered 15, 16, 17 and 18. As described by Berg, these occurrences are:

15 Crushed metarhyolite cut by sparse veinlets containing quartz, calcite, barite, and a few specks of galena.

16 East-northeast-trending 10(?)-ft-wide shear zone in metarhyolite. Zone contains calcite and quartz veins carrying barite and hematite, plus small amounts of galena, chalcopyrite, and pyrite.

17 Barite-calcite veins in iron-stained brecciated metarhyolite. Outcrop of barite-bearing rock is 150 square feet in area.

18 North-striking 10(?)-foot-wide shear zone in brecciated metarhyolite. Zone contains veins and irregular masses of barite and calcite, plus small amounts of hematite and galena.

Rapid examination by Hawley and Associates (1975) of those four localities did not indicate significant mineralization at sites 15 and 16, but localities17 and 18 are much larger and more complex than indicated by the previous reconnaissance, and also show evidence of stratiform nature.

Berg's 17 occurrence is on the north side of Sylburn Peninsula at the contact of the Triassic volcanic-sedimentary unit with the rhyolitic metavolcanics; the mineralized interval probably corresponds with Triassic limestone.

Mineralized rocks consist of elongated masses of about 20% visible coarsely crystalline barite in a limonitic brown dolomite(?) (Figure 6). Barite also forms veins which cut across structure. Chip samples across the visibly barite-bearing rocks contained about 18-37 percent $BaSO_4$; the limonitic dolomite contained 0.48 to 16.3 percent $BaSO_4$ (Table 2).

As exposed along the beach, the mineralized area is about 200 x 200 feet. The mineralized area seems to project inland southeasterly from the beach, as confirmed by soil surveys (Figure 6, Table 2). The soil lines indicate barite mineralization extends at least 400 feet east of the beach.

The barite is accompanied by small amounts of galena and sphalerite; lead appears to correlate with barium (Figure 7) and as much as 7,000 ppm zinc is found with barium-rich soil samples in the area which can be inferred to correlate with the Triassic limestone (Figure 6).

The largest mineral deposit identified on Annette is near Berg' s locality 18, previously described as a 10-foot(?)-wide shear zone in metarhyolite. The deposit is on the north side of the Peninsula adjacent to a protected small boat anchorage.

The deposit is definitely stratiform in character, forming an arcuate outcrop which trends southeast near the beach, but swings to a southwest trend inland (Figure 8). The barite-rich zone apparently coincides with a steep topographic ridge. It lies between rhyolitic metavolcanics (to the east) and limestone and argillite (to the west). The barite zone is at least 700 feet long measured over the arc, and is about 80 feet wide--although the contacts are mostly concealed and the outcrop is not good enough to determine how much high grade barite is within the zone (Hawley and Associates, 1975, p. 4-4).

The barite material varies from coarsely crystalline, as at locality 17, to a fine-grained laminated type with intervening laminations of galena and sphalerite. Assays of chips and grab samples from the locality are given as Nos. 1-8 and 37-38 in Table 3. These samples indicate about 20-50% $BaSO_4$, 0.2-1.5% lead, 0.2-3% zinc, and 0.1-0.6 ounces of silver per ton.

The main trend can also be partly bracketed by soil samples collected on E-W reconnaissance lines south of outcrop. Those samples show strongly barium-enriched zones coinciding with the trend projected from the ridge system.

Reconnaissance through heavy timber south of the soil lines also showed a barite outcrop 550 feet south of the southernmost soil line. This material assayed 25% $BaSO_4$.

Although tonnage and average grade of the body are obviously speculative, the apparent size of the body projected downward through a half-strike length over a 50-foot width which averaged 10 cubic feet/ton would be in excess of 1,000,000 tons (Hawley and Associates, 1975, p. 4-4 to 4-7).

Diamond core drilling on the Berg locality no. 18, indicated that barite mineralization occurs in a complex series of beds composed of limestone, rhyolite, shale and argillite. The beds are not well defined and the barite appears to be present in more than one rock type associated with quartz alteration. Five holes were drilled along two sections. The drill hole assays are summarized in Table 4 and their locations indicated on Figure 2.

TABLE 2
Results of Analyses, Berg Locality No. 17
(From Hawley and Assoc., 1975)
Map numbers refer to Figure 6

Map Number	Sample Number	Cu (ppm)	Pb (ppm)	Zn (ppm)	Au (ppm)	Ag (ppm)	Mo (ppm)	Ba (%)
1.	BP 1	5	20	245	<.02	<.2		.40
2.	BP 2	100	300	7,000	<.02	4.2		3.0
3.	BP 3	60	60	1,450	<.04	.4		2.4
4.	BP 4	<5	10	15	<.02	<.2		.050
5.	BP 5	55	515	1,150	<.02	.4		.43
6.	BP 6	215	440	2,700	<.02	3.0		.13
7.	BP 7	205	110	2,650	<.02	2.0		10.5
8.	BP 8	40	105	1,200	<.02	.2		3.7
9.	BP 9	5	10	20	<.02	.8		.090
10.	BP 10	5	80	255	<.02	1.6		.085
11.	BP 11	5	60	160	<.10	<.2		.115
12.	B 18	25	370	840				.45
13.	B 20	25	155	335				.02
14.	B 14	.002	.003	.028	<.0006	.012		.28
15.	B 15	.002	.006	3.0	<.0006	.058		22
16.	B 16	.002	1.65	.17	<.0006	.13		9.6
17.	B 17	.062	.002	.062	<.0006	.053		5.6
18.	B 19	<.002	.002	1.0	<.0006	.012		11
19.	B 21	<.002	.004	.034	<.0006	.006		.18

TABLE 3

Results of Analyses, Berg Locality No. 18
(From Hawley and Assoc., 1975)
Map numbers refer to Figure 8.

Map Number	Sample Number	Cu (%)	Pb (%)	Zn (%)	Au (oz/T)	Ag (oz/T)	Mo (ppm)	Ba (%)
1.	B 28	.002	.034	.19	<.0006	.058		2.8
2.	B 29	.010	.026	.044	<.0006	.015		28.5
3.	B 24	.026	1.45	.50	<.0006	.70		13.5
4.	B 25	.022	.13	.86	<.0006	.14		20.5
5.	B 23	.002	.08	.92	<.0006	.041		5.1
		(ppm)	(ppm)	(ppm)				
6.	B 26	120	30	4,700				12
7.	B 27	55	25	3,300				12
8.	BP 30	115	255	1,400	.02	.2		.125
					(ppm)	(ppm)		
9.	BP 31	75	180	800	<.02	1.2		.33
10.	BP 32	120	840	3,150	<.02	<.2		.045
11.	BP 33	85	150	800	<.02	<.2		.070
12.	BP 34	35	130	210	<.02	<.2		.050
13.	BP 35	65	545	2,750	<.02	1.0		.26
14.	BP 36	75	390	2,950	<.02	2.0		.60
15.	BP 37	70	65	2,450	<.02	1.6		3.0
16.	BP 38	225	50	5,100	<.02	.6		1.3
17.	BP 39	80	350	3,700	<.02	1.2		1.5
18.	BP 40	60	40	2,300	<.02	.8		4.9
18.5	BP 41	200	10,500	7,250	*	6.6	24	
19.	BP 12	15	420	950	<.02	<.2		.065
19.	BP 13	40	260	1,100	<.02	<.2		.060
20.	BP 14	50	185	380	<.02	2.0		.060
21.	BP 15	50	630	695	<.02	.4		.045
22.	BP 16	45	350	670	<.02	<.2		.040
23.	BP 17	150	450	2,150	<.02	1.2		14.5
24.	BP 18	80	2,250	3,700	<.04	4.2		3.8
25.	BP 19	30	195	620	<.02	<.2		.36
26.	BP 20	45	90	430	<.02	.4		.105
27.	BP 21	30	365	900	<.02	<.2		.055
28.	BP 22	15	360	490	<.02	.4		.055
29.	BP 23	30	145	1,050	<.02	.2		.105
30.	BP 24	20	355	3,250	<.02	.4		.15
31.	BP 25	275	450	6,700	<.02	5.6		6.7
32.	BP 26	110	2,650	10,500	<.02	1.6		3.3
33.	BP 27	45	470	940	<.02	4.2		.155
34.	BP 28	20	270	1,850	<.02	2.0		.15
35.	BP 29	5	55	1,100	<.02	.4		.15
8.	BP 30	115	255	1,400	<.02	<.2		.125
			(%)	(%)	(oz/T)	(oz/T)		
37.	BP 29R		.70	1.6	<.0006	.58		25
38.	BP 40R		.24	.15	<.0006	.38		37

TABLE 4
Summary Results of Drilling, Berg Locality No. 18
(After Hawley, 1978)
Locations indicated on Figure 2

Drill Hole No.	Bearing, Inclination And Depth	Remarks
No. 1	W, 45°, 185 ft	0-26' rhyolite, 26-185' mainly chlorite schist, 150-160' contained 1.09% $BaSO_4$.
No. 2	E, 45°, 103 ft	19-73' limy beds containing barite, galena, and sphalerite; 22-73' averages 38.34% $BaS0_4$.
No. 3	E, 65°, 79 ft	21-69' mineralized section averages 25.88% $BaS0_4$, 51-61' averages 14% Zn.
No. 4	E, 45°, 113 ft	63-82' interval averages 45.29% $BaS0_4$, 34 ppm Ag, 3.4% Pb.
No. 5	E, 65°, 113 ft	7-57' interval averages 14.99% $BaS0_4$.

Mineralization in general appears to dip about 25° west.

Insufficient work was done to determine the tonnage and grade of barite but the results of the drilling and the occurrence of barite outcrops north, south and west of the drill locations indicate that a barite deposit of economic size and grade that could be mined by open pit methods might be present (McCrillis, 1976, p. 1).

The presence of the barite-lead-zinc occurrences on the north side of the Sylburn Peninsula and scattered mineral occurrences on the south side, indicate that the Sylburn Peninsula is a well mineralized locale and could be the site of deposits of lead, zinc, barite, locally with silver values. The complex geology and thick vegetation require additional detailed mapping and soil sampling from brushed lines. The Triassic(?) limestones seem to be the most favorable rocks.

Crab Bay Area

Crab Bay is on the central part of the east coast of Annette Island. As defined on Figure 2 and Figure 4, the Crab Bay area extends four miles north and two miles south of Crab Bay. It is an area of historic prospecting interest, and contains at least two mineralized zones worthy of further prospecting.

As divided on the generalized map, the Crab Bay area is underlain by (1) Silurian or older greenstone, (2) trondhjemite of the Annette pluton, (3) Triassic volcanic and sedimentary rocks and (4) the Cretaceous or Jurassic volcanic-sedimentary unit. In general, younger rocks lie closer to the coast, overlying the older terrane of Annette pluton which contains prominent inclusions and roof pendants of greenstone that dip away from the contact of the pluton. Recognized mineral deposits consist of quartz and quartz-sulfide veins; soil anomalies suggest the possibilities of widely distributed low-grade gold deposits in part of the Triassic volcanic-sedimentary unit, and lead-zinc deposits occur in limestone (or dolomite) near the limestone-rhyolite contact.

The Crab Bay detailed map area is shown in Figure 4. This detailed base map was used by Hawley and Associates (1975) because of the known mineralization in the area. The geology on the base is mainly after Berg (1972), with minor changes by Hawley and Associates, but it needs more revision to be adequate at the scale shown (1 in.= 1,000 ft).

The Triassic units, especially the felsic volcanic rocks and overlying massive limestone, host most of the recognized mineral occurrences. South of Crab Bay, the base of the felsic volcanic unit consists of breccia containing fragments of trondhjemite and greenstone in a volcanic-rich matrix. It probably represents an ancient ash flow that picked up debris as it flowed over the old trondhjemite-greenstone surface. In typical outcrops, the overlying rhyolite-dacite unit is a finely laminated gray quartz-rich rock which probably was a subaerial ash-fall tuff. Local concentrations of magnetite and specular hematite are very characteristic, as are abundant quartz veins which range from less than an inch to several feet wide and form en echelon zones hundreds of feet long.

North of Crab Bay, the position of the contact between the rhyolite unit and trondhjemite of the Annette pluton is indefinite and requires additional study. Hawley and Associates (1975, p. 4-10) believe that the rhyolite tuff grades westward through quartz-rich fragmental tuff to sheared trondhjemite indistinguishable from the tuff, and draw the contact west of the position mapped by Berg (1972).

The rhyolite-dacite tuff is overlain by massive limestone, which is generally gray in color, except near the rhyolite contact where it is a buff-colored massive dolomite. The limestone is cavernous and poorly exposed. In contrast to the rhyolite which supports only minor vegetation, the limestone has a dense forest cover. North of Sink Lake, the massive limestone apparently lenses out, and rhyolite is in contact with conformably overlying thin-bedded limestone and shale.

Mineral deposits observed by Hawley and Associates (1975, p. 4-11) in the Crab Bay area are individual quartz and quartz sulfide veins, stringer lodes of quartz-sulfide veins, ladder vein systems of quartz and quartz-sulfide veins, and a low-grade disseminated chalcopyrite deposit in quartz-fragmental rhyolite tuff. Most of the quartz is white and barren; where mineralized, the sulfide material constitutes from less than one percent to rarely more than 50 percent of the quartz. Vein minerals observed are pyrite, galena, sphalerite, and more rarely chalcopyrite, tetrahedrite, barite and possibly stibnite. Free gold has not been reported, but it is probably present in some quartz veins.

Most of the veins are too weak and too poorly mineralized to be of any interest; the strongest individual sulfide-rich vein was at locality A ("vein A") (Figure 4). This vein is exposed in a stream bottom and is 1.5 ft thick and contains about 30-50% total sulfide over an exposed length of 20 ft. A representative sample of the vein assayed 1.25 percent copper, 1.4 percent lead, and 7 percent zinc.

Sulfide-bearing ladder and stringer lode type vein systems were found in two places in dolomite near the generally poorly exposed rhyolite-dolomite contact near Sink Lake (Berg No. 4; Figure 9) and reported by Berg at another locality (No. 5). Mineralization near this contact is also suspected from stream sediment sample No. 348 (Figure 5), and was found at a locality called Cave Creek as a result of the follow-up of stream sediment sample No. 326 which showed 1,150 ppm lead and zinc. Locally the veins are on a maximum spacing of 2-3 per linear foot and aggregate about one tenth of the rock volume. Sulfides--mostly galena and sphalerite--occur in the quartz veins, and are also disseminated in the dolomite. Barite and stibnite were noted in the Sink Lake (Berg No.4) occurrence and ruby silver has been reported (Berg, 1972). Locally at least, sphalerite and galena are disseminated in dolomite.

Samples collected at Sink Lake and Cave Creek were representative of 5-30 foot widths, or of vein material of the type characteristic of the ladder veins. These samples indicate that at least over wide, well exposed distances mineralization is very weak (Figure 9, Sink Lake), with values generally measured in tenths of one percent lead and zinc. Berg (1972) report an earlier USGS (Koschmann) analysis of: 0.03 oz Au/ton, 9.4 oz/ton Ag, 12.43% Pb, 1.28% Cu, and 0.56% Zn. Presumably this represents one vein in the Sink Lake system.

The main significance of the Sink Lake and Cave Creek occurrences is to indicate the possibility of lead, zinc and perhaps copper and silver mineralization in dolomite over a long strike length. The rhyolite-dolomite contact and favorable zone is only exposed in exceptionally favorable areas, and soil surveys or detailed prospecting may reveal many occurrences in this zone along a strike length possibly measured in miles.

Locally the rhyolitic metavolcanics are also mineralized. White bull quartz veins are characteristic of the unit, but in general they are not metallized--sulfides are not visible and no gold has been reported in typical quartz assays. There are, however, quartz-sulfide veins which have a more local distribution.

Prospecting work in the past has resulted in at least one adit in the rhyolite of the Crab Bay area (Berg No. 1) (Figure 10). The adit is 104 feet long and was probably a gold prospect, although it appears unlikely that anything significant was recovered. A grab sample of the adit face yielded only 0.0006 oz Au/ton and selected vein material from the dump only 0.0035 oz Au/ton. An old prospect pit about 400 feet north of the adit did however have oxidized limonitic quartz which assayed 0.93 oz Au/ton (Hawley and Associates, 1975, p. 4-14) and Koschmann (in Berg, 1972) reported silver values to 20 oz/ton and base metal values to over 10 percent in veins from the adit area. It is believed these were likely non-representative samples, but Koschmann in 1934 undoubtedly had the advantage of much fresher exposures and perhaps guidance from the actual prospectors.

Although metallized veins in Crab Bay metarhyolite appear generally far apart, soil samples suggest the possibility of low grade gold deposits in parts of the unit.

To check on existence of disseminated low-grade mineralization in the metarhyolite, Hawley and Associates (1975, p. 4-14) ran eight soil lines across the unit. The samples were collected by auger at intervals of 50-100 feet. The general locations of these lines are given in Figure 4, and results of analyses are in Table 5.

TABLE 5
Crab Bay Soil Lines
(From Hawley and Assoc., 1975)
Map numbers refer to Figure 4

Sample Number	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)	Au (ppm)	Ag (ppm)
B 133a	5	15	20		<.02	.2
B 133b	5	10	30		<.02	.2
B 133c	<5	10	10		<.02	<.2
B 133d	5	5	15		<.02	.2
B 133e	5	5	20		<.02	<.2
B 133f	15	5	35		<.02	<.2
B 133g	<5	15	20		<.02	<.2
B 133h	<5	10	20		<.10	.4
B 133i	<5	5	15		<.04	<.2
B 133j	<5	5	10		<.02	.2
B 133k	5	5	30		<.02	.2
B 133l	5	5	15		<.02	<.2
B 133m	5	10	35		<.04	<.2
B 133n	5	45	30		.06	<.2
B 133o	5	45	105		<.10	.2
B 133p	5	5	45		.27	<.2
B 133q	<5	5	20		.02	<.2
Hx 8a	5	15	15	<2	<.02	<.2
Hx 8b	<5	10	25	<2	<.02	<.2
Hx 8c	5	10	50	<2	<.02	<.2
Hx 8d	5	5	30	<2	.11	<.2
Hx 8e	<5	5	15	<2	.36	<.2
Hx 8f	<5	<5	5	<2	<.02	<.2
Hx 8g	5	5	15	<2	.14	<.2
Hx 8h	5	5	15	<2	.05	<.2
P 10a	5	15	25	<2	<.02	<.2
P 10b	<5	5	15	<2	<.02	<.2
P 10c	<5	5	10	<2	<.02	<.2
P 10d	5	15	25	<2	<.02	.2
Hx 123a	5	20	30		<.02	.2
Hx 123b	5	15	20		.02	.2
Hx 123c	5	15	15		<.02	.2
Hx 123d	5	25	15		<.02	.2
Hx 123e	5	15	15		<.02	<.2
Hx 123f	5	10	15		<.02	<.2
Hx 123g	5	10	30		<.02	.2
Hx 123h	5	15	55		<.02	.2
Hx 123i	5	35	40		<.02	.2
Hx 123j	5	5	40		<.02	.2
Hx 123k	<5	5	15		<.02	.2
Hx 123l	<5	20	10		.02	.2
Hx 123m	<5	5	25		.06	.2
Hx 123n	<5	10	35		<.02	.2

Sample Number	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)	Au (ppm)	Ag (ppm)
Hx 123o	<5	5	40		.28	.2
Hx 123p	5	15	40		.18	.2
Hx 123q	5	5	25		.04	.2
Hx 123r	5	5	15		<.02	.2
Rx 123s	5	10	45		<.02	.2
Hx 123t	<5	10	20		<.02	.2
Hx 123u	<5	5	30		<.02	.2
Hx 127a	<5	40	30		.90	.2
Hx 127b	<5	15	35		<.02	.2
Hx 127c	<5	5	25		<.02	.2
Hx 127d	<5	10	25		.03	.2
Hx 127e	<5	15	60		.71	.2
Hx 127f	<5	20	15		<.02	.2
Hx 127g	<5	15	45		.13	.2
Hx 127h	<5	15	65		<.02	.2
Hx 127i	<5	10	55		<.02	.2
Hx 127j	<5	15	45		<.02	.2
Hx 127k	5	10	55		.02	.2
Hx 127l	<5	10	15		.02	.2
Hx 127m	<5	10	35		<.02	.2
Hx 127n	<5	10	35		<.02	.2
Hx 127o	<5	5	30		<.02	.2
Hx 127p	10	5	50		<.02	.2
Hx 127q	<5	10	20		<.02	.2
Hx 127r	<5	5	30		<.02	.2
Hx 6a	5	25	40	<2	<.40	.2
Hx 6b	<5	15	35	<2	<.02	<.2
Hx 6c	5	5	70	<2	<.02	<.2
Hx 6d	<5	35	35	<2	<.02	<.2
Hx 6e	<5	10	55	<2	<.02	<.2
Hx 6f	5	60	30	<2	<.10	.2
Hx 6g	<5	15	30	<2	<.02	<.2
Hx 6h	5	10	70	<2	<.02	<.2
Hx 6i	5	10	50	<2	<.02	<.2
Hx 6j	5	5	20	<2	<.02	<.2
Hx 6k	<5	5	35	<2	<.02	<.2
Hx 61	<5	5	10	<2	<.02	<.2
Hx 6m	<5	15	24	<2	<.02	<.2
Hx 6n	<5	5	25	<2	<.02	<.2
Hx 6o	<5	<5	25	<2	<.02	<.2
Hx 6p	5	5	15	<2	<.02	<.2
Hx 54a	5	10	35		<.04	<.2
Hx 54b	<5	15	30		<.02	<.2
Hx 54c	<5	5	20		<.02	<.2
Hx 54d	<5	10	40		<.02	<.2
Hx 54e	<5	20	90		<.10	<.2
Hx 54f	<5	25	110		<.02	<.2
Hx 54g	<5	10	30		<.02	<.2
P 35a	<5	10	5		<.02	<.2
P 35b	5	15	35		<.40	<.2
P 35c	<5	5	5		<.02	<.2
P 35d	<5	5	15		<.04	<.2
P 35e	<5	5	5		<.02	<.2
P 35f	<5	<5	5		<.10	<.2
P 35g	<5	5	5		<.02	<.2

The results show very low amounts of copper, lead, and zinc in most soils, but anomalous gold on lines Hx 8, Hx 123, Hx 127, and B 137. The levels of gold determined ranged from 0.02 ppm, which is considered only possibly real, to 0.90 ppm. The anomalous values are clustered in areas fairly near the contact of metarhyolite and overlying limestone (dolomite).

The very low concentrations of copper, lead and zinc possibly are related to leaching of sulfides from near surface zones. The metarhyolite is very sparsely vegetated, and it is believed this may reflect high soil acidity characteristic of the volcanic unit, which speculatively might tie in with leaching of some base metal values from outcrop.

Hawley and Associates (1975, p. 4-19) found disseminated copper in a unit tentatively identified as sheared crystal tuff at locality B (Figure 4). The mineral is chalcopyrite and it forms $^{1}/_{16}$ - ⅛ inch grains scattered through the rock to the extent of about 0.05 percent copper. Because of a sparsity of pyrite, there is essentially no limonite stain, and only very minor malachite stain. Although it is not of commercial grade, it is apparently similar in occurrence to Berg Locality 11--which was not found, and means that essentially barren looking rocks may be mineralized; as exposed on a rounded knoll the occurrence would not be expected to give rise to a noticeable stream sediment anomaly.

Stream sediments collected in 1975 (Figure 5, Appendix) in the general Crab Bay area suggest the possibility of other mineral deposits not yet found (Hawley and Associates, 1975, p. 4-19). Examples are sample Nos. 343 and 300 which have anomalous copper and molybdenum values; No. 325 anomalous in gold, and Nos.250, 265, and 266 anomalous in zinc. Samples Nos. 326 and 348 have relatively high lead and zinc values and as mentioned earlier, reflect mineralization in dolomite.

Lone Wolf Area

The Lone Wolf prospect is a quartz vein type gold prospect about half a mile east of lower Todd Lake (Figure 11 and location 12 in Figure 2). Some prospecting work has been done in the past as evidenced by several overgrown trenches.

Hawley reports the veins are found in the Cretaceous or Jurassic volcanic and sedimentary series, specifically the dacitic and andesitic volcanic unit. This rock type tends to have a good vegetative cover and is not well exposed near the quartz veins, which form small outcrops and strong float zones. The quartz veins are from 1 to 10 feet in width and are exposed intermittently in a zone 600 feet in length and 200 feet in width. The veins are either parallel or subparallel to structures and are elongated in a northwesterly direction parallel to regional strike. Berg reports a strong quartz vein in the same unit on Todd Lake about ½ mile northwest, and the same unit is host to auriferous veins on Ham Island area.

The quartz has a bluish tint and is only sparsely mineralized. Galena, pyrite and sphalerite were noted as well as several specks of free gold. The gold is associated with green mica (mariposite?) which was noticed near the sample having 0.23 oz/ton gold.

Six chip samples were taken from the Lone Wolf area by Hawley and Associates (1975, p. 4-20). All but one (0.23 oz Au/ton) were very low grade, but all were auriferous (Figure 11). The association of free gold with greenish mica in an apparent salvage or wall rock zone at the site of the highest value suggests that the bulk of the gold could be concentrated near the borders of the veins.

The Lone Wolf will probably be of little interest to larger companies, but might be profitable for further prospecting by individuals. Since it seems likely that the interior of the veins will prove to be relatively barren while the contact with wall rock will be higher grade, prospecting should include trenching across the vein down to bedrock on either side, as well as trenching northwest-southeast to find more veins. It may prove worthwhile to examine a general zone parallel to the contact of the volcanic units (Jv in Berg, 1972) for other similar quartz veins.

Other Mineral Areas

Numerous other mineral localities are known in the Annette Islands Reserve. A few of these may be significant. Berg (1972) compiled a list of known mineral occurrences--either found by Berg or reported earlier. Those occurrences are shown by number symbol on Figure 2 and Figure 5; Berg' s description and analytical data are duplicated in Table 6. Many of these occurrences were looked for and examined during the 1975 season by Hawley and Associates; some could not be found in a reasonable search period; in this case it is assumed that the occurrences are too small for a major development although some could be of interest to an individual prospector.

TABLE 6

Description of Berg's Mineral Occurrences

(From Berg, 1972)

Map location numbers refer to location numbers in Figure 2

Map Loc.	Field Station Number	Description
1	*34A C319a	Three-foot-wide quartz stringer lode in metarhyolite breccia: 0.04 oz./ton Au
1	*34A K409a	One-foot-wide streak of chalcopyrite, galena, and pyrite in quartz vein in metarhyolite: 0.04 oz./ton Au; 20.60 oz./ton Ag; 9.75% Pb; 4.63% Cu; 13.14% Zn
1	*34A K409b	Chalcopyrite, galena, and pyrite in 2-foot-wide quartz vein in metarhyolite: 0.05 oz./ton Au; 13.20 oz./ton Ag; 4.00% Pb; 1.86% Cu; 5.00% Zn
1	*34A K411	Relatively barren quartz vein about 4 feet wide and several hundred feet long in metarhyolite: 0.04 oz./ton Au; 0.92 oz./ton Ag; 0.05% Cu; 0.21% Zn
1	68A Bg461	110-foot-long northeast-trending adit in iron-stained rhyolite microbreccia that contains traces of chalcopy-rite, pyrite, and hematite
2	67A Bg280	Iron-stained north-northeast-trending shear zones up to 10 feet wide and 40 feet long in metarhyolite. Zones contain vuggy quartz and disseminated pyrite

Map Loc.	Field Station Number	Description
3	*34A K412a	1.5-foot-wide quartz vein in metarhyolite: 0.36 oz./ton Au; 0.91 oz./ton Ag; 2.00% Pb; 0.63% Cu; 0.23% Zn
3	*34A K412b	Three-foot-wide quartz vein in shear zone in metarhyolite: 0.43 oz./ton Au; 0.34 oz./ton Ag; 0.64% Pb; 0.85% Cu; 16.75% Zn
4	*34A K414a	Sulfide-bearing quartz lenses and veins in either limestone or metarhyolite. Sulfides, which occur both in the quartz and in the country rock near the quartz, consist of tetrahedrite and galena, plus a little chalcopyrite, covellite, and chalcocite, and a trace of ruby silver: 0.03 oz./ton Au; 9.64 oz./ton Ag; 12.43% Pb; 1.28% Cu; 0.56% Zn
4	68A Bg579	Disseminated magnetite and secondary copper minerals (malachite, azurite) in leucocratic quartz diorite adjacent to northeast-trending fault
4	68A Bg581	Traces of hematite and secondary copper minerals in inch-wide quartz and calcite veinlets in dolomitic limestone
5	68A Bg472	Small stringers and disseminated grains of galena, pyrite, and chalcopyrite in brecciated dolomitic limestone
6	68A Bg547	Veinlets and disseminated grains of magnetite in fault breccia in schist
7	68A Bg497	Traces of chalcopyrite, malachite, pyrite, and hematite in sheared aplite and leucocratic quartz monzonite. Metalliferous minerals occur in iron-stained zones an inch or so wide and about a foot long
8	67A Bg38, 39	Quartz lenses and veins up to 30 feet wide and 100 feet long in phyllite and metarhyolite. Some of the veins contain small amounts of galena, pyrite, and marcasite(?)
9	*34A K145	Small amounts of sphalerite, chalcopyrite, pyrite, and galena in metarhyolite(?)
10	*34A K53(?)	Traces of gold in beach placer material and in quartz float near quartz-bearing slate and graywacke bedrock
11	68A Bg653	Sparsely disseminated chalcopyrite in foliated leucotrondhjemite
12	*34A K142, 416a	Quartz lenses and veins up to 10 feet wide and several hundred feet long in phyllite and fine-grained schist. Quartz and country rock near quartz contain small amounts of disseminated pyrite and galena, and a few specks of gold: 0.71 oz./ton Au; 0.91 oz./ton Ag
13	68A Bg405	Iron-stained quartz veins in zone up to 8 feet wide in dark-gray phyllite
14	68A Bg36, 37, 452	Galena in thin, discontinuous calcite-quartz fissure veins in subhorizontal shear zone up to 20 feet thick and several hundred feet long. Grab sample assayed in July, 1968 by Alaska Division of Mines and Minerals: 1.38 oz./ton Au; 0.42 oz./ton Ag
15	68A Bg84	Crushed metarhyolite cut by sparse veinlets containing quartz, calcite, barite, and a few specks of galena
16	68A Bg89	East-northeast-trending 10(?)-foot-wide shear zone in metarhyolite. Zone contains calcite and quartz veins carrying barite and hematite, plus small amounts of galena, chalcopyrite, and pyrite

Map Loc.	Field Station Number	Description
17	66A Bg208, 68A Bg69	Barite-calcite veins in iron-stained brecciated metarhyolite. Outcrop of barite-bearing rock is 150 square feet in area
18	66A Bg198, 68A Bg76	North-striking 10(?)-foot-wide shear zone in brecciated metarhyolite. Zone contains veins and irregular masses of barite and calcite, plus small amounts of hematite and galena
19	68A Bg90	Quartz veinlets containing chalcopyrite, pyrite, hematite, and secondary copper minerals in brecciated sericitized leucotrondhjemite. Veinlets occur in breccia zones up to an inch wide and several feet long
20	67A Bg294, 295	Sparse veinlets and disseminated grains of chalcopyrite, pyrite, malachite, azurite, and hematite in brecciated leucotrondhjemite and felsic aphanite. Also present at locality are foot-thick pieces of quartz float containing small amounts of chalcopyrite, pyrite, malachite, and magnetite
21	68A Bg196	Trace of malachite in conglomerate
22	66A Bg182, 184	Partly serpentinized dunite containing scattered thin seams of chrysotile asbestos and sparse veinlets and disseminated grains of chromite. A random sample of massive dunite contained 0.029 ppm Pt, but less than 0.005 ppm Rh and Pd
23	No field station	Location approximate. Disseminated chalcopyrite in leucotrondhjemite
24	67A Bg340	Sparsely disseminated pyrite and chalcopyrite and traces of malachite in schist
25	67A Bg456a	Thin stringers and streaks of pyrite and chalcopyrite in schist and gneiss
26	68A Bg270	Very sparsely disseminated pyrite and chalcopyrite in schist and hornfels
27	69A Bg101	Sparse pyrite, arsenopyrite, and chalcopyrite(?) in iron-stained, sheared, and intricately jointed very fine grained schist. Abundant calcite veinlets
28	69A Bg91	Pyrite, magnetite, and galena(?) in sparse calcite veinlets up to a quarter of an inch thick and 2 or 3 inches long in foliated trondhjemite
29	69A Bg90	Same as 69A Bg91
30	69A Bg84a	Sparse galena, hematite(?), and pyrite in iron-stained quartz veins and pods up to 10 feet thick in schistose trondhjemite
31	69A Bg34	a) Iron-stained zones (gossan) associated with dark-green intermediate dike about 10 feet thick; b) Scattered irregular quartz veins, iron-stained zones, and inch-long pods of magnetite and hematite in crudely schistose leucotrondhjemite

*Location approximate. Mapped and sampled in 1934 by A. H. Koschmann and H. Coombs, U.S. Geological Survey. Data are from their unpublished field notes. Samples analyzed by chemical and spectrographic methods by E. T. Erickson and G. Steiger, USGS. 1934.

Additional occurrences were found in the prospecting done by Humble (Exxon) Oil Co. in 1969-70. Humble collected numerous rock chips and stream sediment samples in the northern part of the Annette pluton, especially near a low grade porphyry copper occurrence east of the Sylburn Peninsula northeast of Hemlock Island and in a copper-bearing area in Annette Bay.

The porphyry area, referred to on Figure 12, Figure 13 and Figure 14 as the Hemlock Island area, is essentially the same as Berg localities 19 and 20; it is on and near the main logging road. Figures 12 and Figure 13 show rock chip sample locations and geology mapped by Humble. Figure 14 shows geology and soil and rock sample locations in the Hemlock Island area from the 1975 study (Hawley and Associates, pl. 4-26 to 4-30). Analyses that accompany these figures are listed in Table 7, Table 8 and Table 9.

Mineralization consists of chalcopyrite-bearing veins, and chalcopyrite, magnetite and hematite disseminated in leucotrondhjemite. Copper-bearing veins as much as 10 feet wide form a northeast-striking set which appear to be concentrated in mafic-dike zones. Disseminated chalcopyrite is in leucotrondhjemite near contacts with normal trondhjemite and quartz diorite. Although the vein zones have as much as 0.5-0.6% copper, the disseminated rock appears to contain an order of magnitude less.

The copper occurrence at Annette Bay (location A, Figure 2 and Figure 5) is mostly in schist. Although very sparsely disseminated chalcopyrite was seen at a few places, most of the copper occurs as secondary malachite in the foliation planes of the schist. Maps and analyses after Humble data are shown in Figure 15 and Table 10.

TABLE 7

Sample Analyses for Figure 12

Sample #	PPM Cu	PPM Pb	PPM Zn	PPM Mo
37	8	14	200	
38	10	4	28	
39	10	4	44	
40	8	8	20	
41	16		16	20
42	8		6	
42-A	24	6	78	
43	480	10	54	
44	26	8	32	
45	12	18	34	16
46	6	2	36	
47	6	8	84	
48	16	2	10	
49	1150		4	40
50	6800		6	
50-A	540	2	4	
51	24	4	2	
52	480	6	6	5
53	16	2	8	
54	6	16	150	20
55	54	30	110	
56	62	2	126	
66	14	4	48	
67	8		10	
68	356	2	14	
69	4		6	
70	14	2	6	
71	12	8	50	
72	10	2	2	
73	1760	2	2	
74	14	2	2	
75	14		10	24
76	12	2	26	
77	16	4	42	
78	14	6	74	
80	4	8	56	
81	6	4	52	
82	12	4	30	5
83	6	4	12	

TABLE 8

Sample Analyses for Figure 13

ANR Series Samples No.	ppm Copper	ppm Lead	ppm Zinc
16	5	<10	10
17	<5	<10	15
18	5	<10	15
19	90	<10	85
20	190	10	95
21	105	10	85
22	30	10	65
23	20	10	65
24	20	<10	70
25	95	30	300
58	<5	10	5
59	<5	10	10
60	5	10	10
61	15	10	20
62	5	10	15
63	5	20	60
64	10	20	75
65	5	10	50
66	5	10	50
67	10	10	50
68	15	20	150
69	10	10	55
70	15	10	50
71	35	10	65
73	20	20	100
91	45	30	225
92	65	40	340
93	10	20	100
95	75	30	270
96	110	40	280
97	135	10	120
98	265	40	670
99	30	20	390

TABLE 9

Sample Analyses for Figure 14

Sample #	Cu	Pb	Zn	Comments
Hg 14	450			10' chip sample of leuco-trondhjemite with weakly disseminated chalcopyrite.
P 49	5500			Grab sample in leuco-trondhjemite with accompanying dark aphanitic dike rock.
P 50	6900			Chalcopyrite, pyrite in quartz veins with leuco-trondhjemite dike in normal trondhjemite.
HX 80a	50	25	210	Soil samples, some disseminated chalcopyrite
HX 80b	10	70	570	and sphalerite.
HX 80c	475	15	190	a-c sheared trondhjemite.
HX 80d	45	15	315	d-g rhyolite.
HX 80e	50	30	390	e-g graphitic faults.
HX 80f	85	45	800	
HX 80g	70	20	490	
HX 81	220	20	180	HX 81-87 - 100' spaced, 10' chips of sheared
HX 82	60	20	160	rhyolite.
HX 83	260	<20	260	
HX 84	60	<20	200	
HX 85	300	<20	460	
HX 86	540	<20	200	
HX 87	600	<20	300	
HX 88		20	680	HX 88 - 7' chip sample of manganiferous zone between rhyolite and greenstone.
HX 89		<20	1100	HX 89, 89a - Grab of manganiferous rock.
HX 89a				

TABLE 10

Sample Analyses for Figure 15

Sample #	PPM Cu	PPM Pb	PPM Zn	PPM Mo
Ann 1	350	6	26	6
2	370	6	38	4
3	468	6	38	
57	88	6	36	
58	84	12	38	
59	150	6	24	
60	450	22	72	
61	40	6	40	
62	40	6	48	
63	52	10	46	
64	54	8	38	
65	238	8	50	
16	66	6	36	
17	128	6	26	
18	58	6	34	

Another area of general interest is the Metlakatla Peninsula where possible metalliferous products from Yellow Hill rocks are iron and platinum metals. Platinum has been determined in some Yellow Hill dunite at 0.029 ppm (Berg 1972) and 0.02 ppm (Hawley, 1975, p. 4-33), which is similar to the level characteristic of other Alaska-type ultramafics. Clark and Greenwood (1972) report that the platinum metals are locally concentrated with magnetite in some Alaska-type ultramafics, with as much as 30 ppm in magnetite and 0.04 ppm in olivine from the Union Bay dunite (Clark and Greenwood, 1972). If magnetite in the Yellow Hill body is enriched in platinum group metals, they might be produced by magnetic separation liberated in any crushing operation.

Possibilities for iron ore would depend first of all on the existence of a magnetite-hornblende pyroxenite zone on the west side of Yellow Hill. If the Yellow Hill body is like other Alaska zoned ultramafics, 10-15% magnetite could be expected in such a zone, which could be a future resource of iron ore.

Nonmetallic Mineral Resources

Dunite from Yellow Hill is quarried for local road material. It is conceivable that production and shipping of a crushed dunite for road building material could be feasible in the future, particularly because of near tidewater location. The only other current use of olivine is in foundry sand, but it is doubtful if Metlakatla olivine could compete against olivine mined, for example, in Oregon.

ENERGY RESOURCES

Uranium

One claim for radioactive materials was staked in 1955, on the south shore of Lake Tamgas, near its outlet (sec. 35, T. 78 S., R. 92 E.) (USBM, 1973) .This claim was probably staked without knowledge of the reserve status of the land. No other information is available on this property and no other mention of radioactive materials has been reported on the Annette Islands Reserve.

Hydroelectric Potential

The island has a hydro power potential which is presently developed only at Purple Lake. The primary system develops 3,000 KW and is backed up by a diesel system also of 3,000 KW. Potential power lakes include Spine, Dubuque and Melanson.

RECOMMENDATIONS FOR FURTHER WORK

Recommendations regarding possible further study of the mineral potential of the Annette Islands Reserve are summarized below:

1. Sylburn Peninsula, sec. 19, 20, 21, 28, 29, T. 77 S., R. 92E.:

   Further work on the numerous barite-lead-zinc occurrences in this area should be guided by the recommendations and results of the 1980 field work on the Sylburn

Peninsula by Hawley and Associates. This study was not available for the compilation of this report.

Appropriate geophysical studies, including an electromagnetic survey, would be useful in evaluating the potential for massive sulfide deposits. These geophysical studies could be made along the existing brushed and surveyed lines emplaced for previous detailed soil sampling.

2. Crab Bay Area, T. 78 S., R. 93 E.:

   A. Gold

   The possibility of low grade gold deposits within the metarhyolite should be further investigated. Further soil sampling is indicated.

   B. Lead, zinc, possible copper and silver

   Several anomalies in these elements reported along the metarhyolite-dolomite contact suggest soil surveys and detailed prospecting.

3. Lone Wolf gold prospect, sec. 1, T. 77 S., R. 92 E., Berg Location No. 12:

   Gold-bearing quartz veins may be of interest to the small operator. Further work should include northwest-southeast trenching to locate additional veins. Similar gold-bearing quartz veins may be found by examining the contact between the metavolcanic and metasedimentary members of unit KJvs (units Jv and Jsg in Berg, 1972).

4. Southeastern Annette Island, sec. 15, 16, 17, 19, T. 79 S., R. 93 E.:

   Unmapped Triassic limestone and dolomite may occur on southeastern Annette Island (Hawley and Associates, 1975, p. 2-12). If so, detailed prospecting is justified, because these rocks are mineralized in the Crab Bay area.

5. Yellow Hill Dunite, Sec. 16, 17, 20, 21, T. 78 S., R. 92 E.:

   Mapping by Taylor (1967) and Hawley and Associates (1975) indicate that this is a zoned ultramafic intrusive similar to others found in southeastern Alaska. A potential magnetite iron ore deposit with possible platinum credits on the west margin of this intrusive should be further delineated by additional magnetometer work. Further work is needed to better characterize the phases of this poorly exposed intrusive. This might include: 1) sampling and analyzing all rock and mineral phases for platinum and related elements Fe, Cr, Ni, V, Ti, Cu; 2) trenching in areas of poor exposure and 3) prospecting the beach of Smuggler's Cove.

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APPENDIX

Results of Analyses, Stream Sediment Samples, Annette Islands Reserve, Alaska
(Sample locations recorded on Figure 5)

NOTE: Field numbers without letter prefix (like Hx, B, P, etc.) are from samples collected by Humble Oil Company and analyzed by Rocky Mountain Geochemical Laboratory. All letter-prefixed numbers collected in 1975, and analyzed by Skyline Labs, Inc., Wheat Ridge, Colorado.

Map No. (fig.)	Field No.	Cu	Pb	Zn	Mo	Au	Ag	Other
				(all values in parts/million)				
1	Hx 79	15	35	65				
2	Hx 78	5	30	35				
3	Hx 77	165	20	50				
4	Hx 76	125	15	20				
5	Hx 75	20	5	25				
6	Hx 74	20	20	15				
7	Hx 73	10	15	15				
8	Hx 72	10	15	20				
9	Hx 103	10	10	75	<2			
10	B 74	<5	5	5	2			
11	Hx 104	45	25	90	2			
12	Hx 71	10	20	25				
13	Hx 70	15	5	15				
14	B 75	5	5	55	2			
15	Hx 105	20	20	70	<2			
16	Hx 106	5	15	70	<2			
17	P 58	145	20	50				
18	Hx 113	45	20	130	2	<.04	.2	
19	Hx 107	5	20	150	<2	<.04	.2	
20	B 76	5	5	15	2			
21	Hx 108	15	20	150	<2	<.04	.2	
22	P 57	40	30	180				
23	B 97	5	10	20				
24	B 77	10	5	70	2			
25	Hx 109	20	35	195	2	.10	.2	
26	B 88	15	30	90				
27	B 96	5	15	15				
28	B 89	15	15	80				
29	B 78	20	10	145	2	<.10	.2	
30	Hx 110	45	35	195	<2	<.04	.2	
31	B 90	5	15	45				
32	B 91	10	25	120				
33	111	25	30	130				
34	110	25	10	120				
35	P 56	55	20	75				
36	B 79	5	10	70	2			
37	B 80	5	10	100	2	<.10	.2	
38	109	25	30	300				
39	-	-	-	-				
40	108	25	20	95				
41	107	10	10	65				
42	106	15	20	65				

Map No. (fig.)	Field No.	Cu	Pb	Zn	Mo	Au	Ag	Other
				(all values in parts/million)				
43	105	25	40	135				
44	112	5	30	60				
45	113	15	20	40				
46	114	70	30	165				
47	25	70	70	130				
48	26	25	40	70				
49	B 92	20	20	145				
50	B 93	15	15	225				
51	B 94	5	15	160				
52	162	5	10	35				
53	161	15	10	60				
54	163	15	10	35				
55	164	20	10	45				
56	Hx 102	5	15	55	<2			
57	191	5	10	30				
58	B 95	15	25	165				
59	150	25	20	180				
60	149	30	10	160				
61	27	15	40	50				
62	28	20	40	70				
63	29	5	20	35				
64	30	35	30	170				
65	31	40	90	325				
66	104	10	120	100				
67	103	25	70	155				
68	102	20	110	450				
69	101	15	120	195				
70	117	15	20	75				
71	Hx 111	25	30	190	<2	<.10	.2	
72a	B 81	5	5	15	2			
72b	B 73	5	10	25				
73a	B 82	15	10	130	2	<.20	.2	
73b	74	20	30	130				
74	Hx 112	10	40	230	2	<.04	.2	
75	115	20	40	195				
76	100	20	40	285				
77	99	15	40	140				
78	32	15	50	150				
79	148	35	10	95				
80	147	30	10	90				
81	190	5	10	15				
82	189	5	10	30				
83	Hx 101	10	15	45	<2			
84	194	5	20	40				
85	192	15	20	50				
86	146	25	10	100				
87	34	65	120	270				
88	-	-	-	-				
89	36	45	50	200				
90	75	5	10	40				
91a	B 83	5	10	70	2			
91b	76	5	30	165				
92a	B 84	5	570	775	2	<.10	.6	
92b	77	10	160	150				

Map No. (fig.)	Field No.	Cu	Pb	Zn	Mo	Au	Ag	Other
				(all values in parts/million)				
93	37	50	30	145				
94	143	10	10	55				
95	142	5	10	35				
96	193	15	20	40				
97	-	-	-	-				
98	165	5	10	20				
99	166	20	20	55				
100	152	10	10	100				
101	145	20	10	90				
102	144	20	20	235				
103	42	25	20	115				
104	78	10	200	345				
105	79	5	20	50				
106a	B 85	10	160	440	<2	<.04	.4	
106b	80	15	20	95				
107	116	10	50	310				
108	43	30	60	335				
109	38	45	30	260				
110	39	15	20	75				
111	40	25	20	120				
112	41	15	20	85				
113	141	45	20	145				
114	196	15	10	40				
115	197	10	10	20				
116	167	20	20	75				
117	44	35	50	400				
118	45	30	40	220				
119a	B 86	5	80	245	<2	<.04	.2	
119b	81	15	30	190				
120a	B 87	5	25	220	2	<.20	.2	
120b	82	15	30	330				
121	63	10	30	330				
122	46	25	20	265				
123	47	25	20	175				
124	151	65	20	205				
125	Hx 99	5	10	50	<2			
126	188	45	10	100				
127	186	5	10	15				
128	128	15	20	50				
129	153	30	10	110				
130	48	155	40	265				
131	65	15	90	450				
132	66	10	160	435				
133	67	10	30	85				
134	84	10	10	50				
135	85	20	20	85				
136	86	20	20	55				
137	87	35	20	160				
138	69	5	10	45				
139	49	35	20	140				
140	206	60	30	165				
141	155	15	20	55				
142	156	10	20	40				
143	198	20	20	65				

Map No. (fig.)	Field No.	Cu	Pb	Zn	Mo	Au	Ag	Other
				(all values in parts/million)				
144	168	40	20	120				
145	68	15	30	90				
146	158	35	20	90				
147	159	25	20	75				
148	154	10	10	25				
149	205	15	10	90				
150	51	5	10	15				
151	50	30	20	135				
152	72	20	20	215				
153	71	15	20	130				
154	70	10	20	60				
155	89	20	30	100				
156	88	25	40	250				
157a	B 22	25	20	140	<2			
157b	90	30	20	190				
158	91	45	20	145				
159	6	105	30	85				
160	52	15	20	75				
161	5	70	40	130				
162	4	30	30	105				
163	207	15	20	70				
164	203	10	40	45				
165	204	10	30	35				
166	199	35	60	70				
167	200	20	10	60				
168	169	25	10	70				
169	184	5	10	20				
170	183	5	10	20				
171	201	20	20	55				
172	160	5	20	15				
173	209	110	20	85				
174	2	10	20	35				
174.5	53	20	20	80				
175	3	35	30	90				
175.5	54	30	20	65				
176	55	20	10	90				
177	92	15	20	330				
178	93	20	20	260				
179	94	5	20	120				
180	1	15	20	90				
181	7	30	30	250				
182	8	35	30	170				
183	202	15	20	45				
184	203	5	20	25				
185	140	15	30	70				
186	170	15	20	45				
187	182	5	20	25				
188	B 98	5	10	20				
189	171	5	10	30				
190	9	30	30	90				
191	10	35	20	90				
192	11	30	20	90				
193	12	20	20	70				
194	13	5	20	30				

Map No. (fig.)	Field No.	Cu	Pb	Zn	Mo	Au	Ag	Other
				(all values in parts/million)				
195	14	5	20	25				
196	15	5	20	20				
197	16	60	30	150				
198	17	30	30	35				
199	18	25	20	55				
200	19	5	20	10				
201	68	15	30	90				
202	20	5	10	15				
203	21	15	10	30				
204	95	70	50	690				
205	96	60	50	925				
206	97	20	100	295				
207	98	20	80	345				
208	64	10	20	20				
209	63	15	20	55				
210	62	5	10	10				
211	61	5	10	5				
212	139	10	20	45				
213	138	15	40	50				
214	172	5	20	15				
215	173	35	20	85				
216	P 62	10	20	45				
217	181	15	20	65				
218	B 99	<5	10	20				
219	180	10	10	35				
220	134	10	20	25				
221	124	15	20	35				
222	59	5	10	5				
223	60	5	10	10				
224	22	5	10	20				
225	23	10	10	40				
226	58	10	10	15				
227	125	25	30	20				
228	133	20	20	45				
229	135	20	20	40				
230	136	25	20	50				
231	137	20	30	40				
232	-	-	-	-				
233	175	10	10	30				
234	179	50	40	70				
234.5	Hx 10	5	20	90	<2			
235	178	5	10	25				
235.5	Hx 9	5	15	25	<2			
236	123	25	20	60				
237	122	20	20	20				
238	121	30	10	25				
239	120	35	20	55				
240	119	5	10	5				
241	118	15	10	20				
242	Hx 34	5	10	5	2			
243	Hx 33	5	10	15	16			
244	Hx 32	5	5	20	2			
245	126	35	20	40				
246	132	95	20	40				

Map No. (fig.)	Field No.	Cu	Pb	Zn	Mo	Au	Ag	Other
				(all values in parts/million)				
247	174	35	10	55				
248a	Hx 121	5	20	30	<2	<.10	.2	
248b	177	5	10	25				
250	B 12	5	60	165	<2			
251	Hx 120	5	20	45	6	<.10	.2	
252	131	15	20	25				
253	Hx 29	<5	5	5	<2			
254	Hx 30	<5	5	5	<2			
254.5	Hx 35	<5	20	10	2			
256	Hx 36	5	5	5	2			
257	Hx 28	5	5	10	2			
257.5	Hx 27	5	5	10	2			
258	127	15	20	30				
259	128	15	10	40				
260	130	10	20	15				
261	P 78	<5	25	15	2			U <2
262	P 79	<5	15	15	2			U <2
263	P 80	5	20	40	2			U <2
264	Hx 129	5	15	50	2	<.02	.2	
265	P 13	5	95	220	<2			
266	P 12	15	20	273	14			
267	P 11	5	15	45	<2			
268	Hx 128	10	15	30	2	<.02	.2	
269	P 83	5	15	15	<2			U <2
270	B 129	10	15	25	2			U <2
271	P 82	<5	20	25	<2			U <2
272	B 121	5	40	25	<2			U 2
273	P 77	5	10	15	2			U <2
274	P 76	<5	10	5	<2			U <2
275	Hx 19	<5	5	15	<2			
276	Hx 21	5	5	25	2			
277	Hx 20	5	10	25	2			
278	Hx 22	5	10	10	2			
279	Hx 23	<5	5	10	2			
280	Hx 24	5	10	25	2			
281	Hx 25	<5	5	10	<2			
282	Hx 26	5	5	15	8			
283	B 41	5	5	15	2			
284	B 42	5	10	20	2			
285	B 43	5	5	5	<2			
286	B 44	5	5	10	2			
287	P 21	5	5	5	2			
288	P 20	<5	5	5	<2			
289	P 75	<5	15	15	<2			U <2
290	B 122	<5	10	10	<2			U <2
291	P 81	<5	5	5	<2			U <2
292	B 128	20	25	40	2			U <2
293	B 130	15	10	20	2			U 2
294	P 84	<5	10	25	<2			U <2
295	Hx 12	15	5	80	<2			
296	B 13	5	10	35	<2			
297	P 87	<5	10	20	<2	<.02	<.2	
298	B 134	5	5	20	<2	<.02	.2	
299	B 135	5	10	95	<2	<.10	<.2	

Map No. (fig.)	Field No.	Cu	Pb	Zn	Mo	Au	Ag	Other
				(all values in parts/million)				
300	B 127	245	25	165	8			U 2
301	B 124	5	15	30	2			U 2
302	B 123	5	15	20	2			U <2
303	B 118	5	15	50	2			U <2
304	B 117	5	15	40	2			U <2
305	P 73	5	20	30	2			U 3
306	B 35	<5	5	<5	<2			
307	B 36	5	10	20	<2			
308	B 37	5	5	30	<2			
309	B 38	5	5	15	<2			
310	B 39	5	5	10	<2			
311	B 40	5	5	5	2			
312	P 19	5	5	10	10			
313	B 73	<5	5	10	<2			
314	B 72	<5	5	10	2			
315	B 71	5	15	5	2			
316	B 70	<5	5	10	2			
317	B 34	5	10	25	2			
318	B 33	5	5	20	<2			
319	B 30	5	5	30	<2			
320	B 119	5	15	50	<2			U <2
321	B 120	20	15	50	<2			U 3
322	B 125	65	35	95	2			U 2
323	B 126	75	30	135	6			U 4
324	B 140	10	10	60	<2	<.20	.2	
325	B 139	20	20	100	2	.15	.4	
326	B 141	95	1150	1150	<2	<.04	1.4	
327	B 131	25	30	55	2			U 2
328	BP 62	35	15	115	10		<.2	
329	B 31	5	20	25	2			
330	B 32	5	10	40	2			
331	B 69	<5	5	10	2			
332	B 68	<5	5	5	2			
333	B 67	<5	5	5	<2			
333.5	B 66	<5	10	5	2			
334	B 64	<5	5	5	2			
334.5	B 65	<5	5	5	2			
335	B 63	<5	5	5	2			
336	B 62	<5	<5	5	2			
337	B 61	5	10	10	2			
338	B 60	5	5	20	2			
339	B 59	5	15	25	2			
340	B 18	5	5	10	2			
341	Hx 18	15	5	55	<2			
342	5	5	30	2				
343	B 8	115	10	60	22			
344	B 9	40	25	90	2			
345	BP 63	40	25	75	4		<.2	
346	BP 64	5	15	65	2		<.2	
347	B 6	5	5	60	<2			
348	B 7	15	45	220	2			
349	B 10	50	45	85	2			
350	Hx 7	15	20	55	2			
351	Hx 5	<5	15	25	<2			

Map No. (fig.)	Field No.	Cu	Pb	Zn	Mo	Au	Ag	Other
				(all values in parts/million)				
352	P 12	15	20	275	14			
353	P 16	5	5	5	2			
354	P 15	5	5	20	2			
355	P 3	<5	5	15	<2			
356	P 4	5	15	20	<2			
357	P 5	5	5	30	<2			
358	P 6	5	10	35	<2			
359	P 7	<5	5	15	<2			
360	P 8	<5	10	25	<2			
361	B 5	5	10	50	2			
362	B 4	<5	5	20	2			
362.5	Hx 90		20	125	2	<.02	.2	
363	Hx 91		20	170	2	.02	.2	
364	Hx 92		20	115	2	.02	.2	
365	Hx 93		15	110	<2	<.02	.2	
366	Hx 94		35	100	<2	<.10	.2	
367	B 53	15	25	75	<2			
368	Hx 56a	5	15	25	2			
369	Hx 4	20	5	15	<2			
369.5	BP 61	50	25	90	2		<.2	
370	B 3	<5	5	10	<2			
371	Hx 3	5	10	55	<2			
372	B 2	5	10	30	<2			
373	Hx 2	<5	5	15	<2			
374	P 2	<5	5	5	2			
375	P 1	<5	<5	10	<2			
376	P 14	5	5	5	2			
377	-	-	-	-	-			
378	Hx 17	45	10	70	<2			
379	Hx 16	20	5	50	<2			
380	Hx 15	25	5	110	<2			
381	Hx 14	15	5	130	<2			
382	Hx 1	5	5	35	<2			
383	B 1	<5	5	15	2			
384	Hx 55	5	20	70				
385	B 52	5	10	35	<2			
386	Hx 53	20	35	195	<2			
387	P 22	5	15	25	2			
388	P 23	5	5	15	<2			
389	Hx 37	5	15	30	2			
390	Hx 57	30	5	70	2			
391	BP 51	15	35	50	2		<.2	
392	BP 55	5	5	20	<2		<.2	
393	P 24	<5	10	15	2			
394	Hx 40	35	15	20	2			
395	Hx 39	45	15	35	2			
396	Hx 38	5	10	15	<2			
397	P 31	5	10	40	2			
398	P 32	10	20	50	2			
399	P 33	15	20	55	2			
400	P 34	<5	10	15	2			
401	P 36	5	25	50	2			
402	Hx 68	5	10	30	2			
403	Hx 41	<5	5	5	<2			

Map No. (fig.)	Field No.	Cu	Pb	Zn	Mo	Au	Ag	Other
				(all values in parts/million)				
404	P 25	5	15	10	2			
405	BP 50	5	15	30		.2	2	
406	P 40	10	10	40	<2			
407	B 45	5	15	60	<2			
408	P 30	<5	10	10	6			
409	P 29	5	5	5	<2			
410	B 113	10	15	85	<2			
411	P 27	5	130	40	2			
412	P 26	<5	35	10	<2			
413	Hx 43	5	5	5	<2			
414	Hx 42	5	20	10	<2			
415	Hx 66	10	10	50	2			
415.5	BP 60	15	15	45		<.2	<2	
416	Hx 44	5	35	35	<2			
417	Hx 45	5	15	20	<2			
418	Hx 46	5	10	40	<2			
419	Hx 47	10	20	45	<2			
420	P 28	5	5	5	<2			
421	B 51	<5	10	10	<2			
422	Hx 52	25	15	65	2			
423	Hx 51	20	10	40	<2			
424	Hx 50	5	10	35	<2			
425	Hx 49	15	10	40	<2			
426	Hx 48	85	15	130	<2			
427	Hx 64	5	5	10	2			
428	Hx 63	15	20	50	2			
429	P 64	5	10	20	2			
430	B 100	<5	15	30	<2			
431	B 46	15	15	45	2			
432	P 65	5	10	15	2			
433	B 101	5	10	30	<2			
434	Hx 62	20	10	70	2			
435	P 66	5	15	15	2			
436	B 47	45	20	80	<2			
437	B 54	5	5	30	2			
438	B 55	<5	5	5	<2			
439	B 56	5	5	10	<2			
440	B 48	20	20	95	2			
441	B 105	10	10	60	<2			
442	B 103	<5	5	25	<2			
443	B 102	15	10	45	<2			
444	P 67	5	20	20	<2			
445	P 68	5	50	45	2			
446	P 69	<5	20	10	<2			
447	P 70	<5	15	10	<2			
448	P 71	5	20	15	<2			
449	Hx 61	25	5	55	2			
450	Hx 60	45	5	145	2			
451	B 104	5	10	60	6			
452	B 106	15	10	65	<2			
453	B 107	5	15	35	<2			
454	B 108	10	15	40	<2			
455	B 109	35	25	85	<2			
456	B 110	25	25	85	<2			

Map No. (fig.)	Field No.	Cu	Pb	Zn	Mo	Au	Ag	Other
				(all values in parts/million)				
457	B 111	15	15	85	<2			
458	B 57	5	5	10	<2			
459	B 116	55	15	115	<2			
460	B 115	50	15	170	2			
461	B 112	25	15	65	<2			
462	Hx 58	45	5	120	2			
463	Hx 59	5	5	35	2			
464	B 114	20	15	115	<2			
465	B 58	5	5	10	<2			
466	Hx 56b	5	5	20	2			
467	B 50	5	5	15	<2			
468	P 48	<5	<5	5	2			
469	B 49	5	10	20	<2			
469.5	P 47	10	5	50	2			
470	P 46	15	10	55	2			
471	P 44	<5	5	20	2			
472	P 45	20	10	65	2			
473	P 43	5	10	15	<2			
474	P 42	15	10	35	<2			
475	P 41	10	15	30	2			

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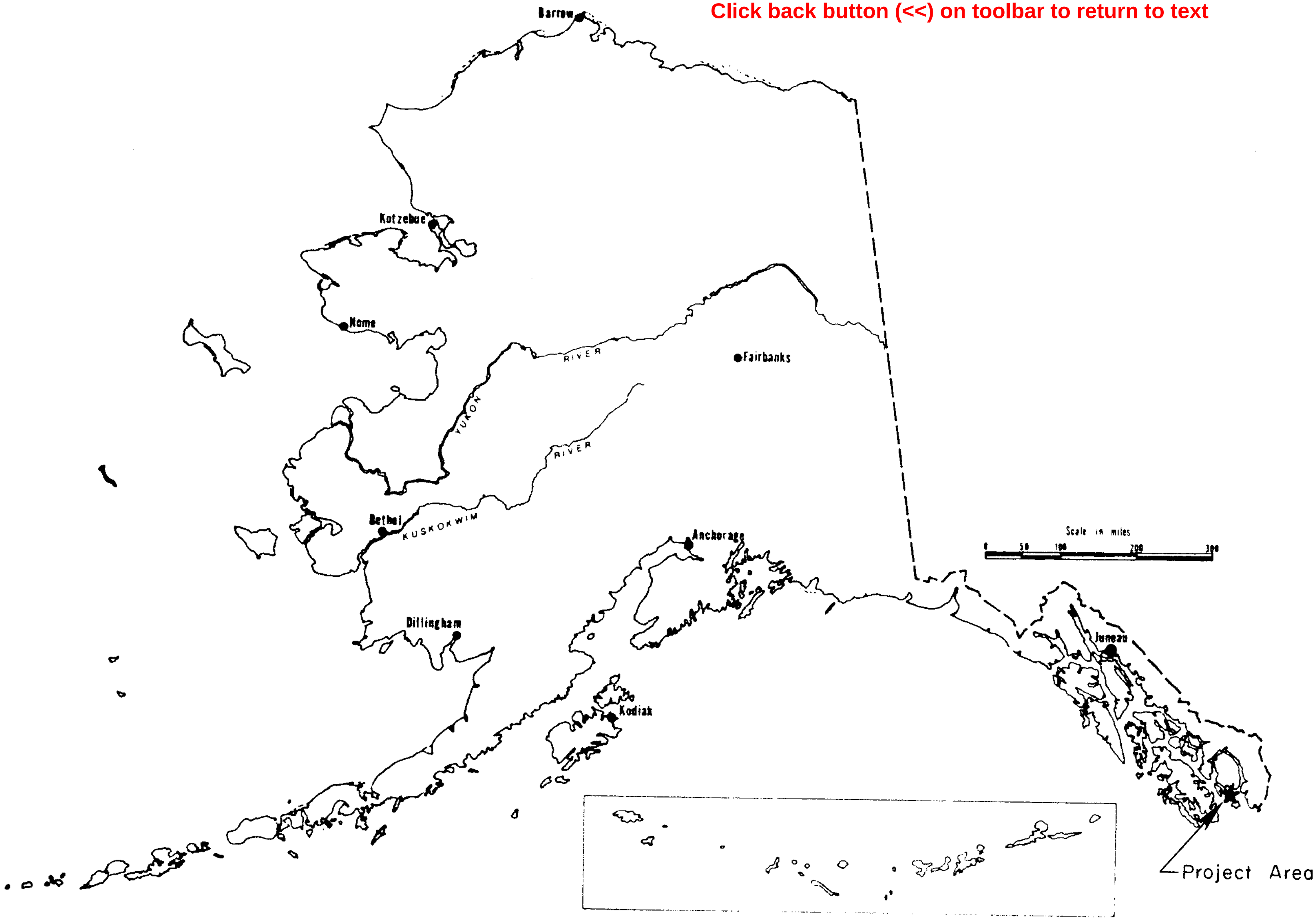

Figure 1. Project location map, Annette Island Reserve.

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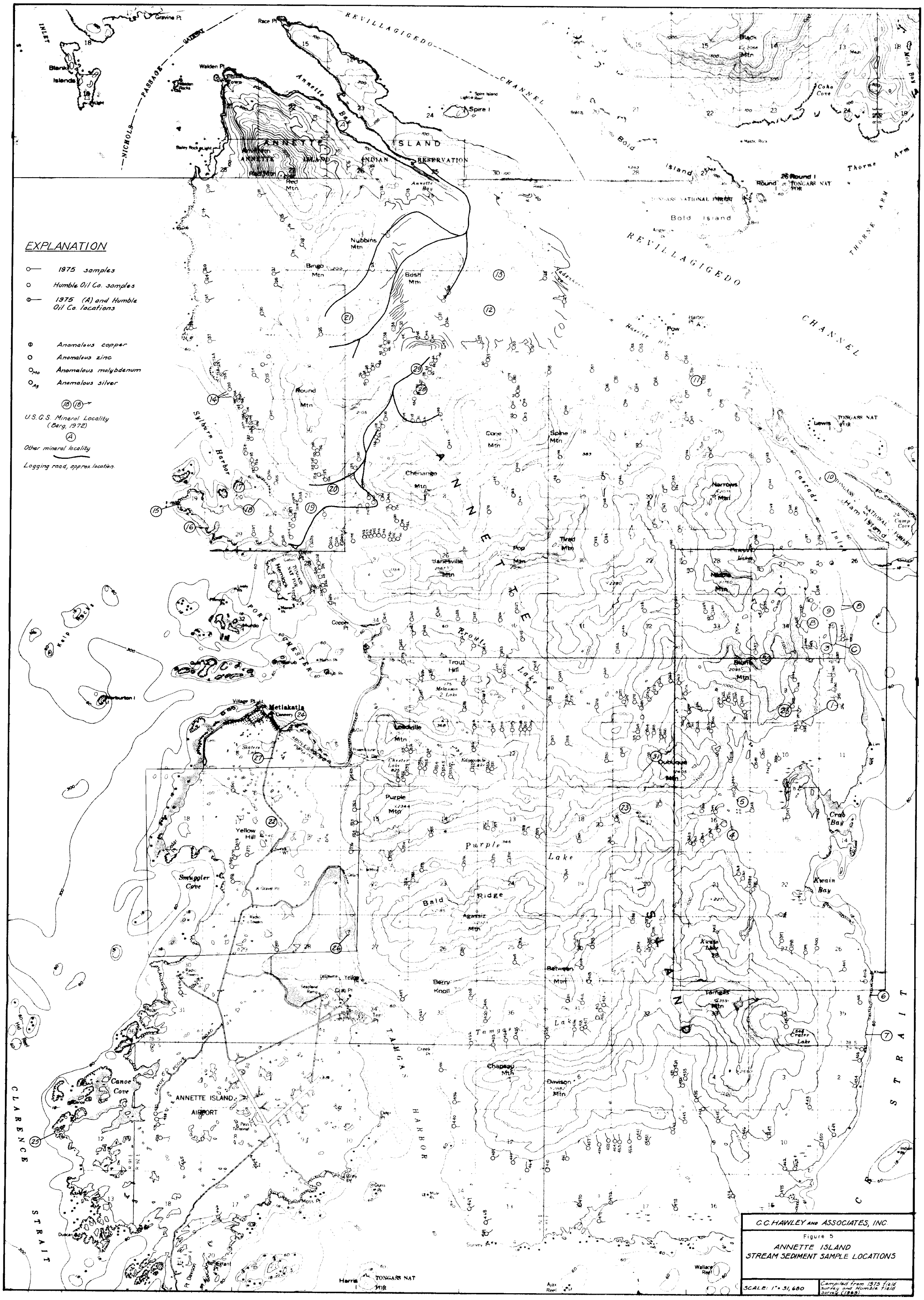

Figure 2. Generalized geologic (bedrock) map of the Annette Islands Reserve, Alaska.

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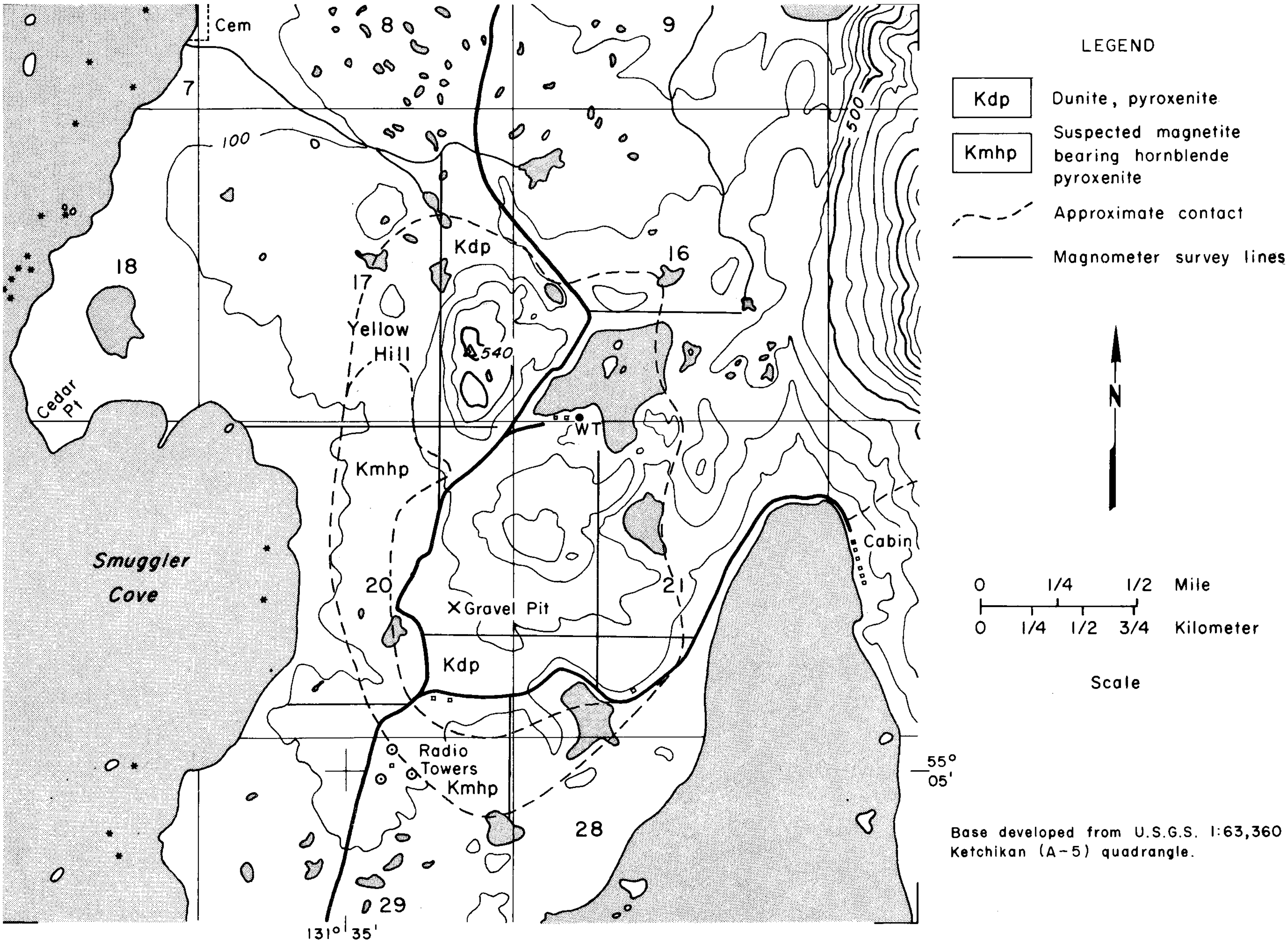

Figure 3. Generalized map of the Yellow Hill intrusive.

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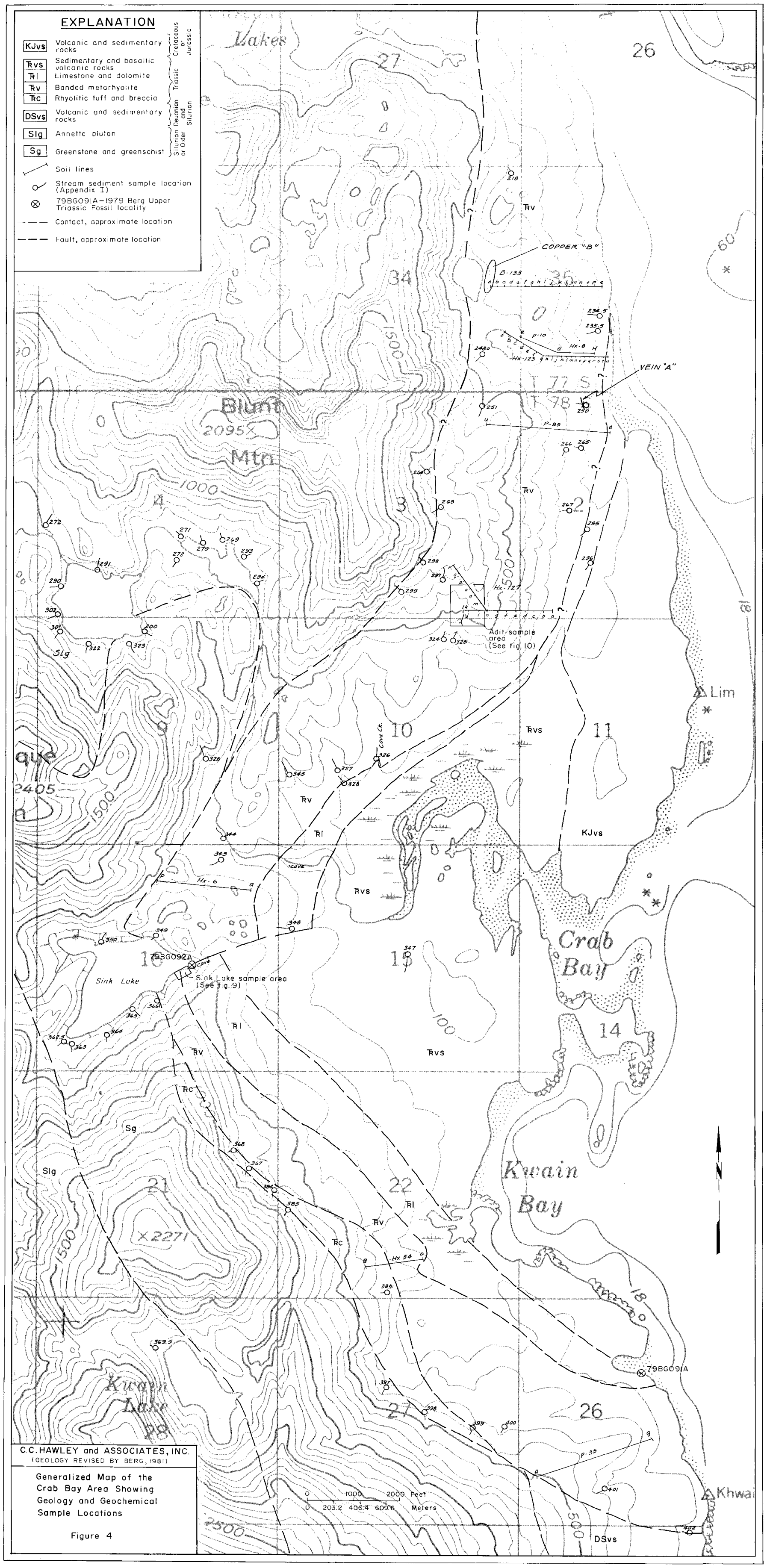

Figure 4. Generalized map of the Crab Bay Area showing geology and geochemical sample locations.

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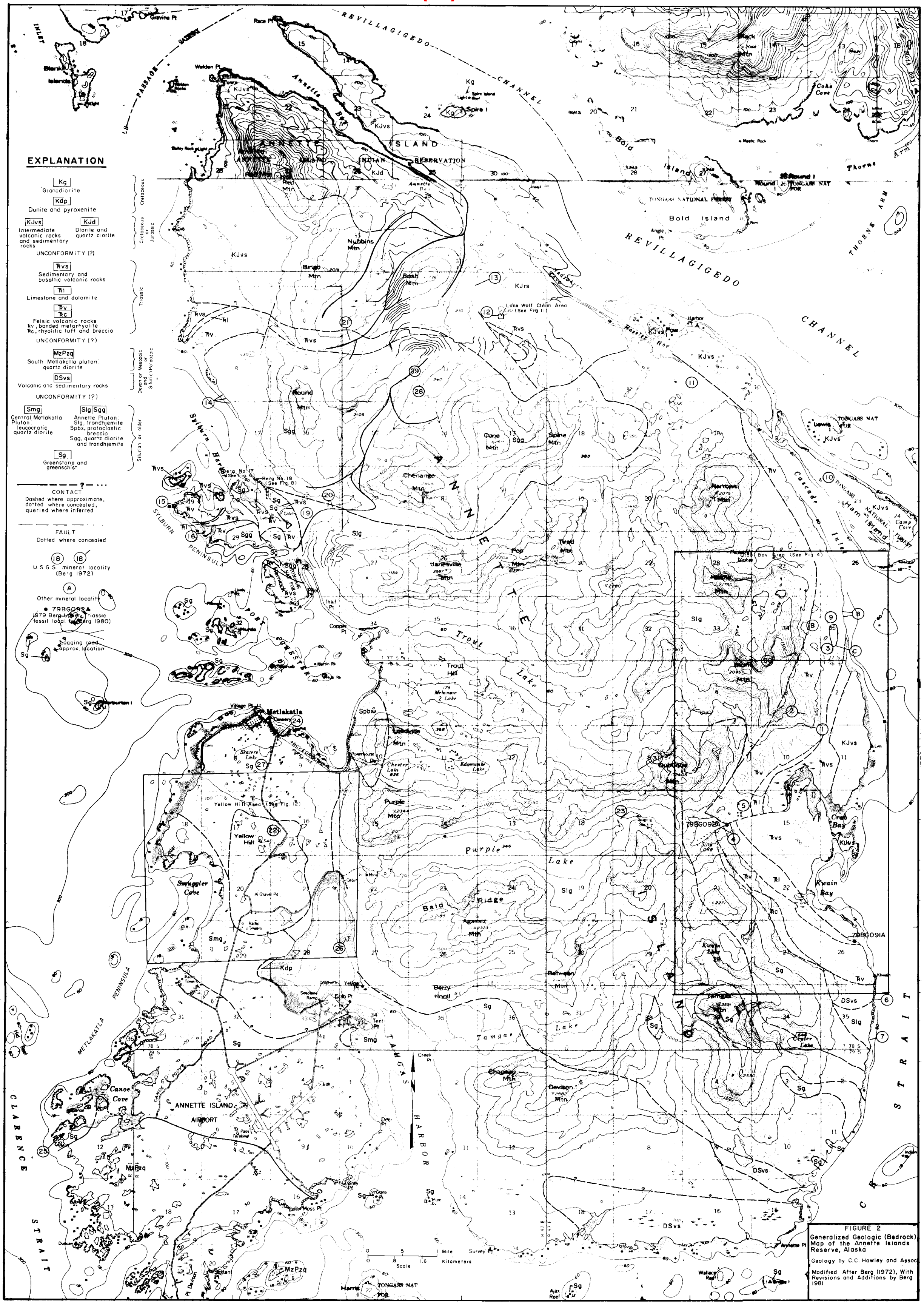

Figure 5. Annette Island stream sediment sample locations.

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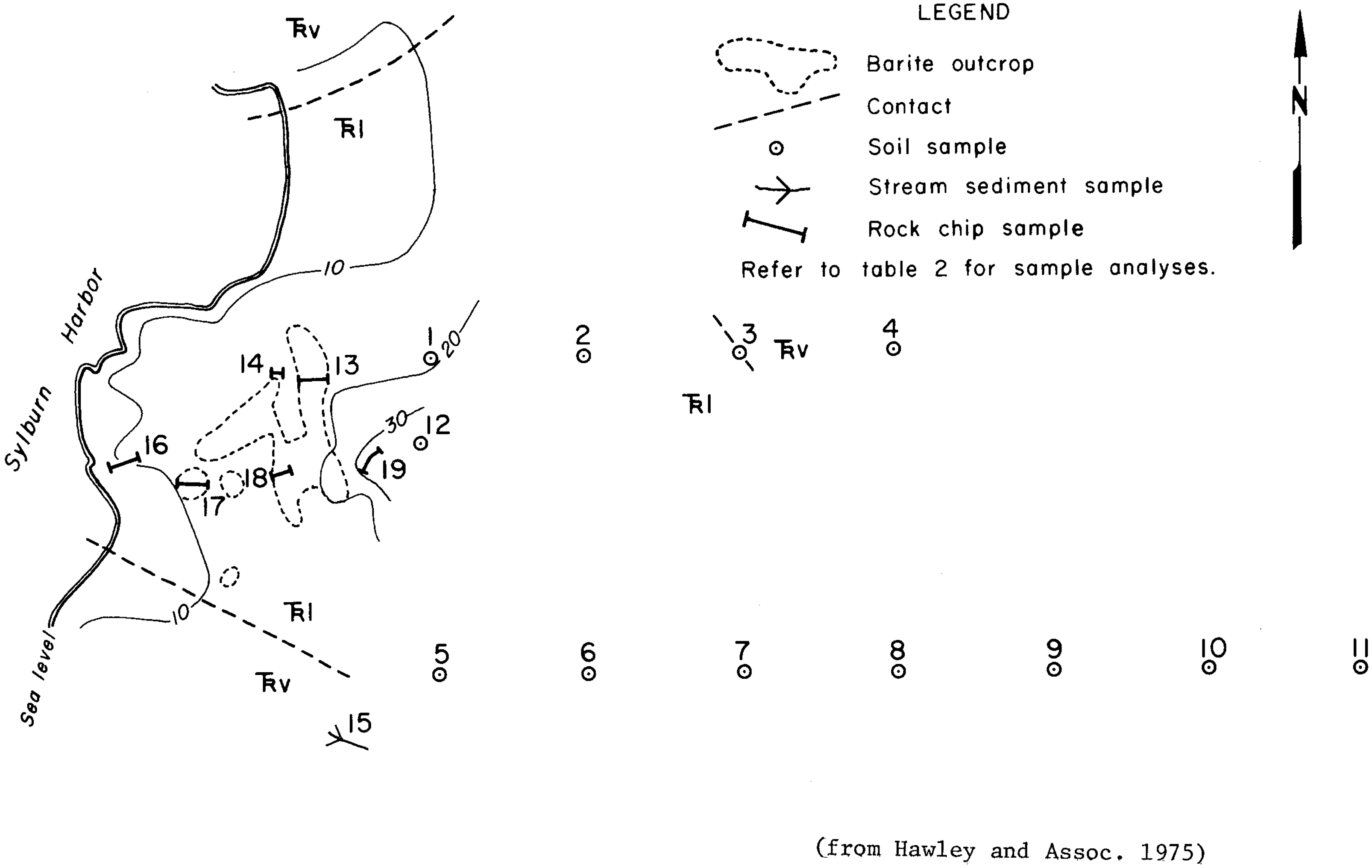

Figure 6. Berg mineral occurrence No. 17.

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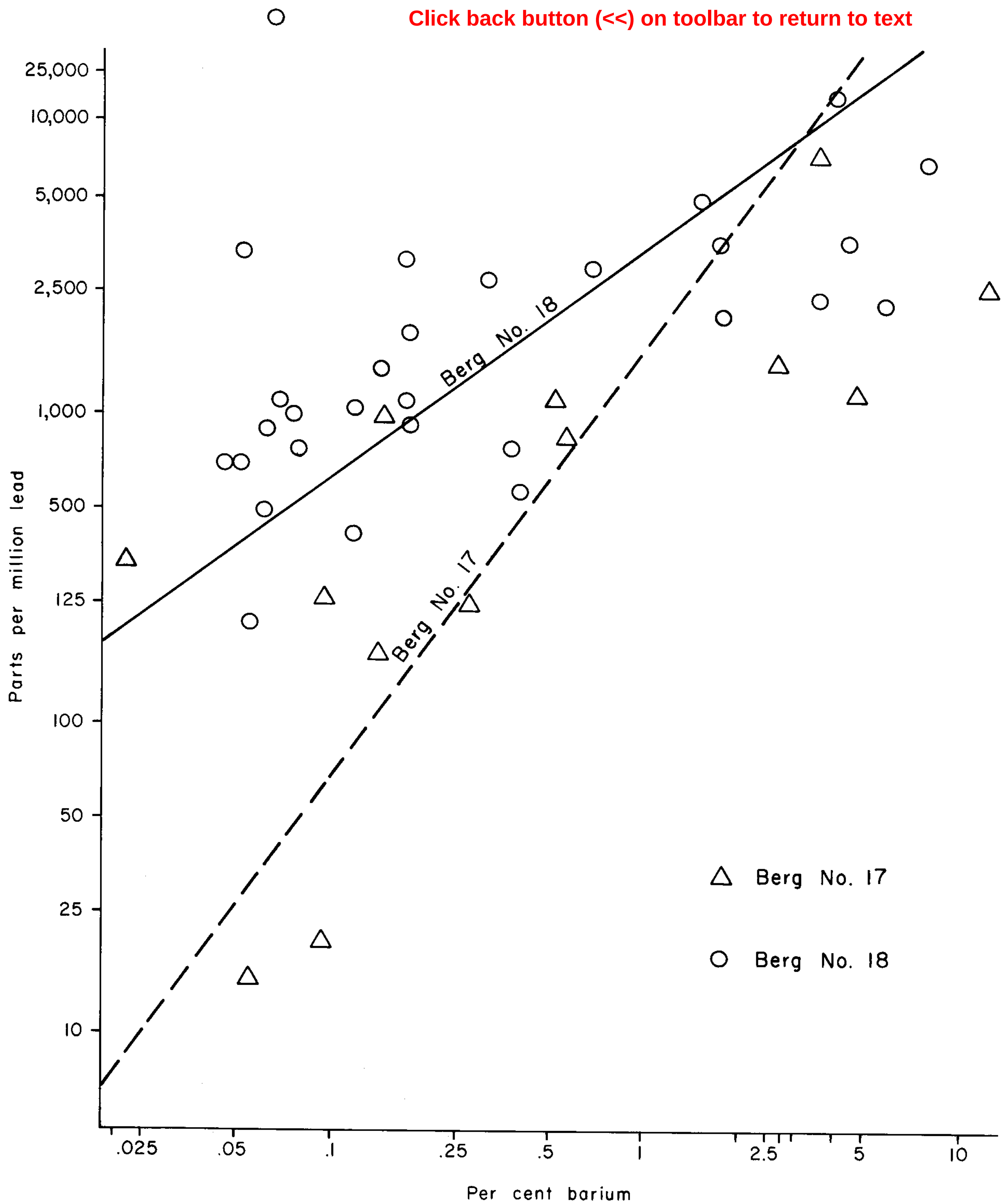

Figure 7. Correlation of lead and barium at Berg localities No. 17 and No. 18.

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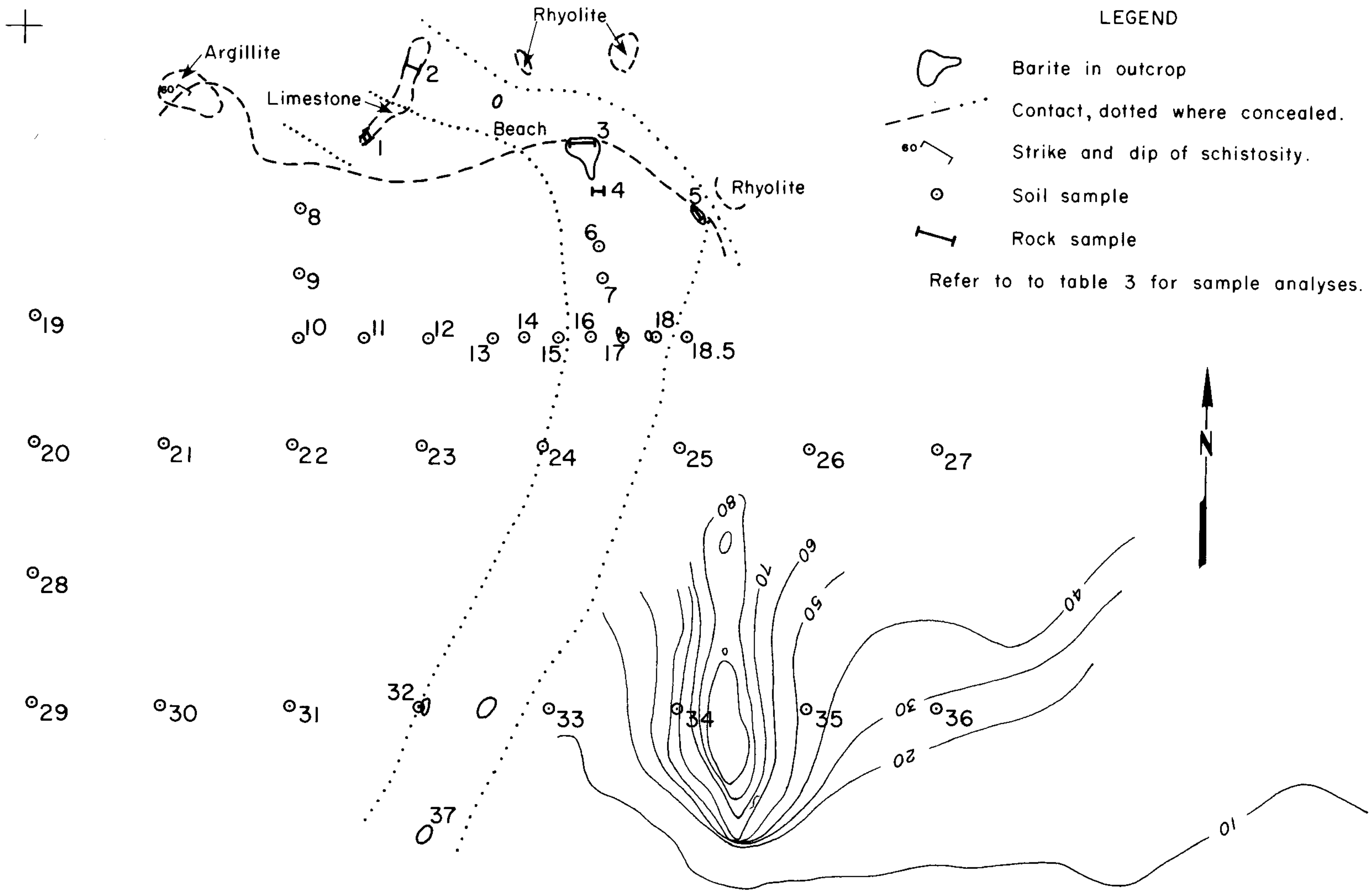

Figure 8. Berg mineral occurrence No. 18.

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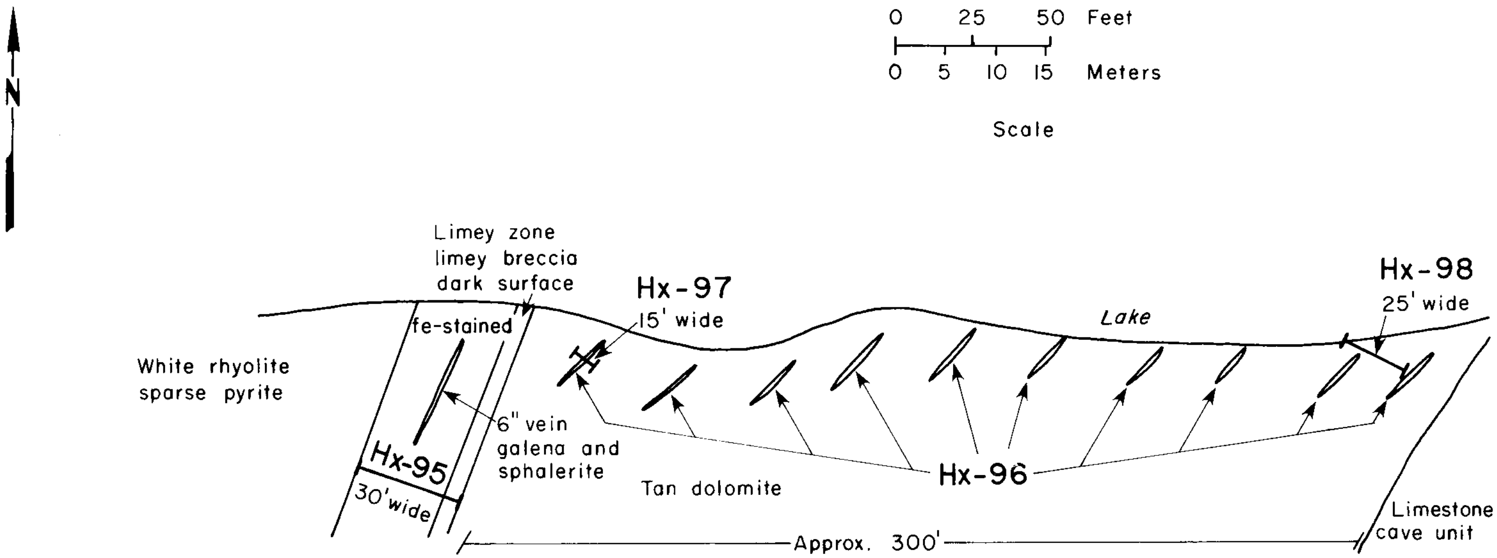

LEGEND

Rock samples

Hx - 95 Vein material in limey layer sphalerite, galena, barite chips across 30'

Hx - 96 Grab sample from quartz veins (pods) in dolomite – sphalerite, galena, hematite, tetrahedrite, malachite and stibnite?

Hx – 97 Chips across 4", 2" and smaller veins and dolomite. 15" wide.

Hx – 98 5' spaced chips of dolomite, no vein material. Galena, sphalerite and stibnite?

Sample Number	Cu (%)	Pb (%)	Zn (%)	Au (oz/T)	Ag (oz/T)	Sb PPM	Ba PPM
Hx – 95	.002	.021	.26	<.0006	.032	4	100
Hx – 96	.016	1.5	.11	.0038	.41	70	1,500
Hx – 97	.088	.52	.63	.0009	1.1	400	15
Hx – 98	.004	.16	.090	<.0006	.076	24	200

Figure 9. Sink Lake, Berg locality No. 4.

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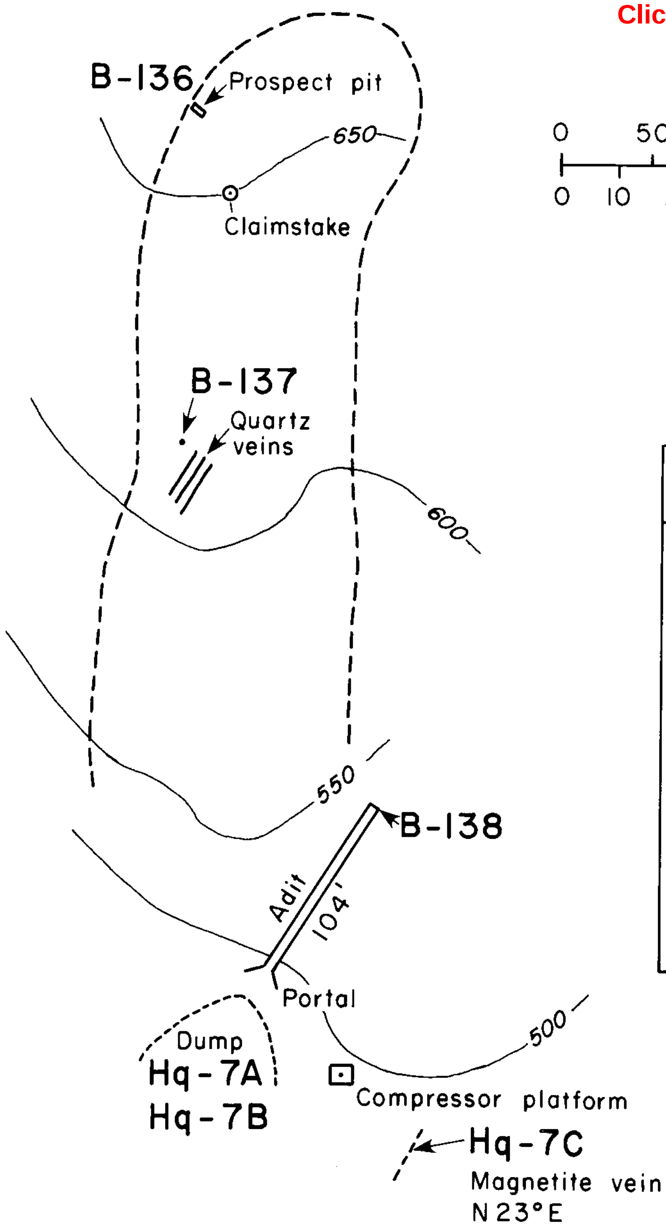

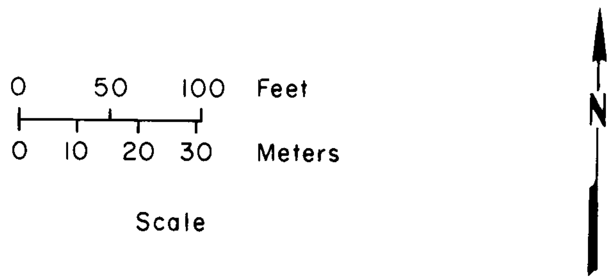

Gold oz/T	Sample Number	Description
.93	B-136	Grab of reddish rocks from prospect pit near claimstake -pyritic.
.0041	B-137	Grab of reddish rocks at prospect pit south of sample B-136.
.0006	B-138	Grab at end of adit.
.0035	Hq-7A	Vein material on dump.
ND	Hq-7B	Rhyolite on dump.
ND	Hq-7C	Hematite-magnetite vein.

Figure 10. Sketch map of adit area near Crab Bay.

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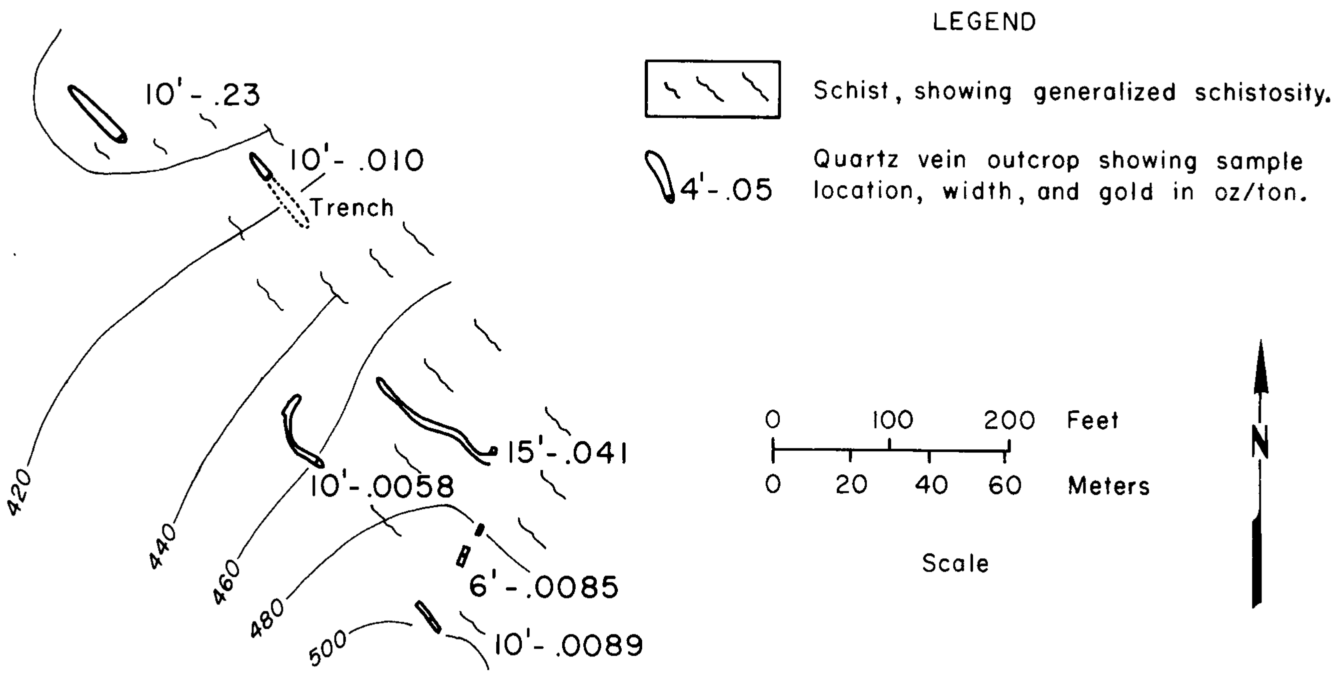

Figure 11. Lone Wolf claim area.

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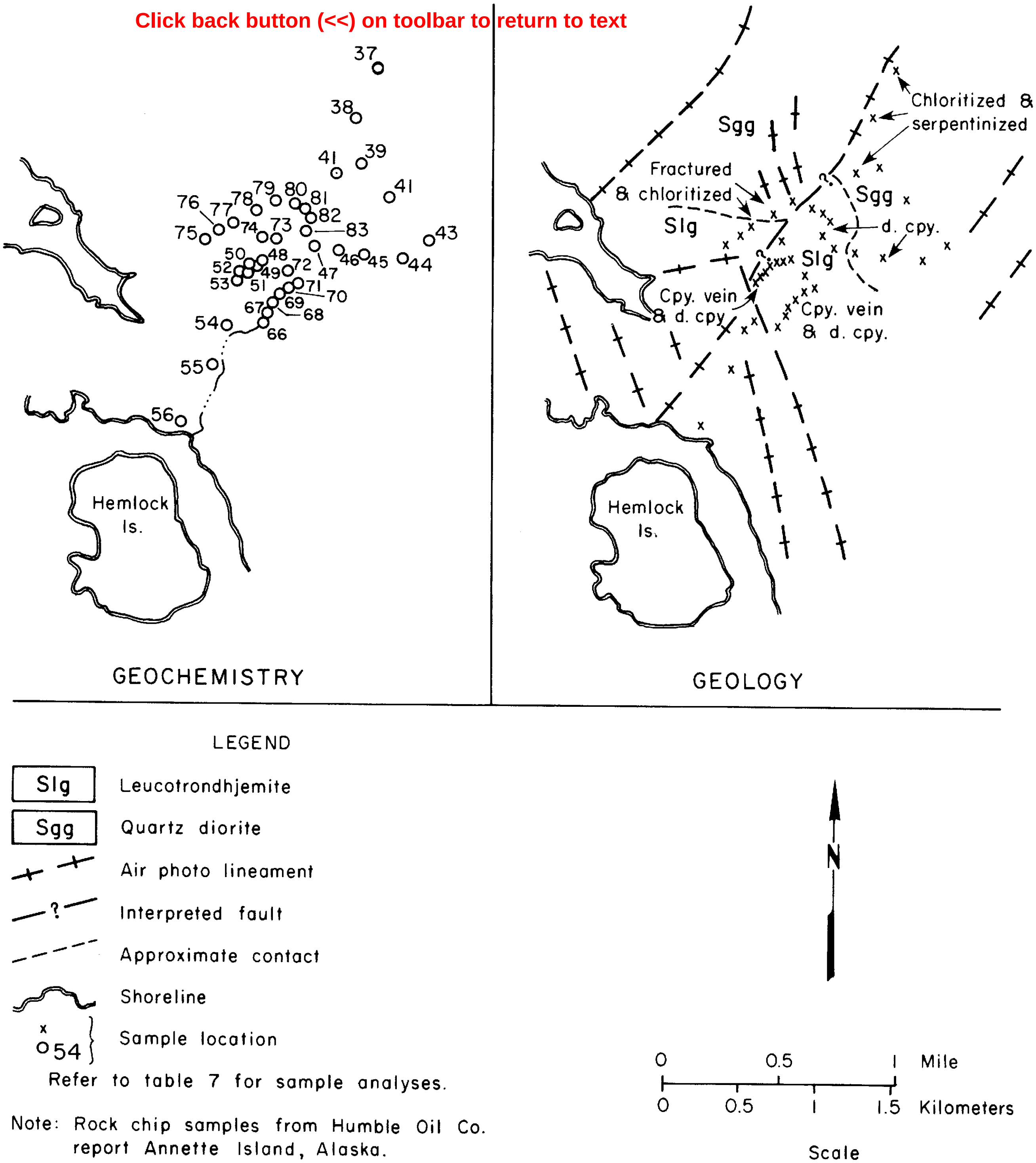

Figure 12. Hemlock Island area, rock chip samples.

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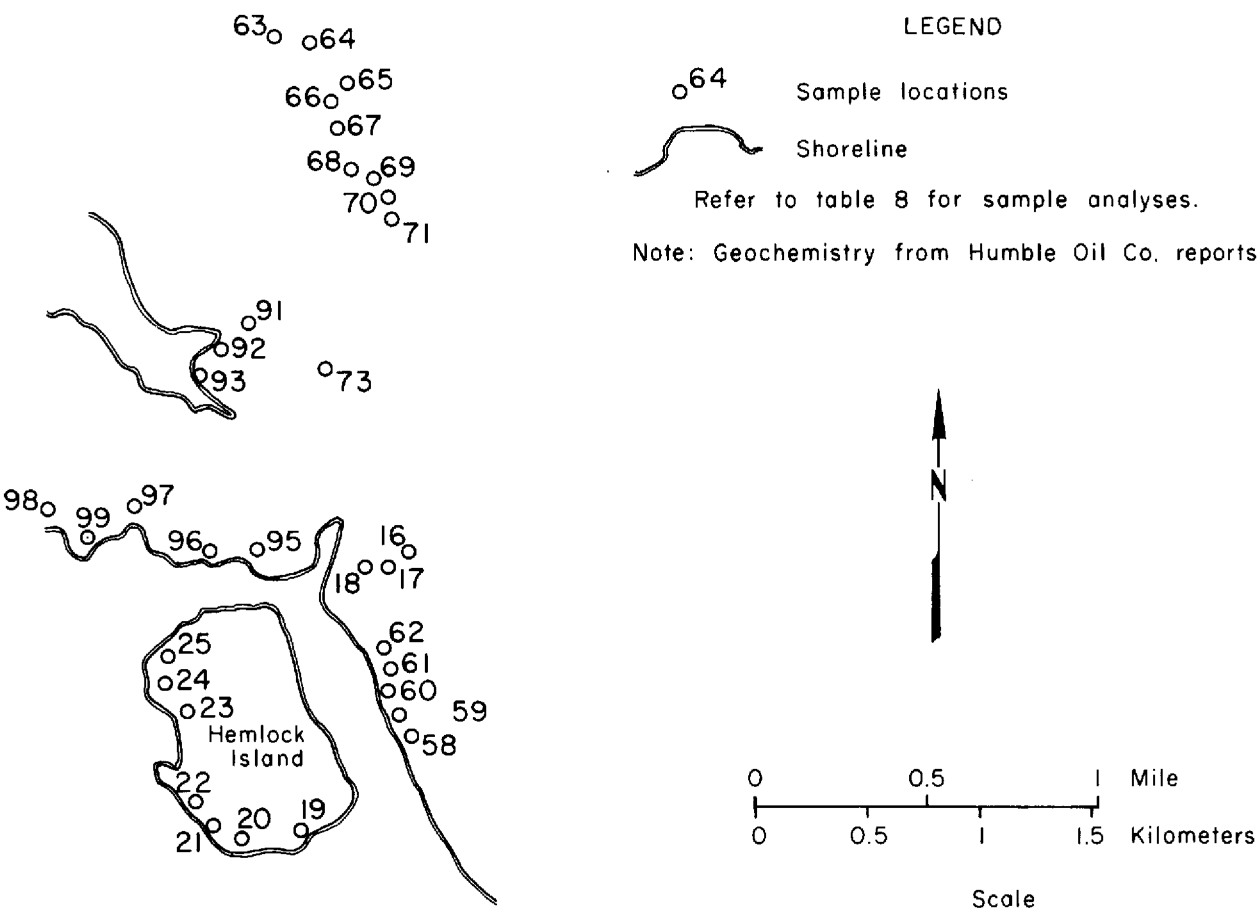

Figure 13. Hemlock Island area, additional rock chip samples.

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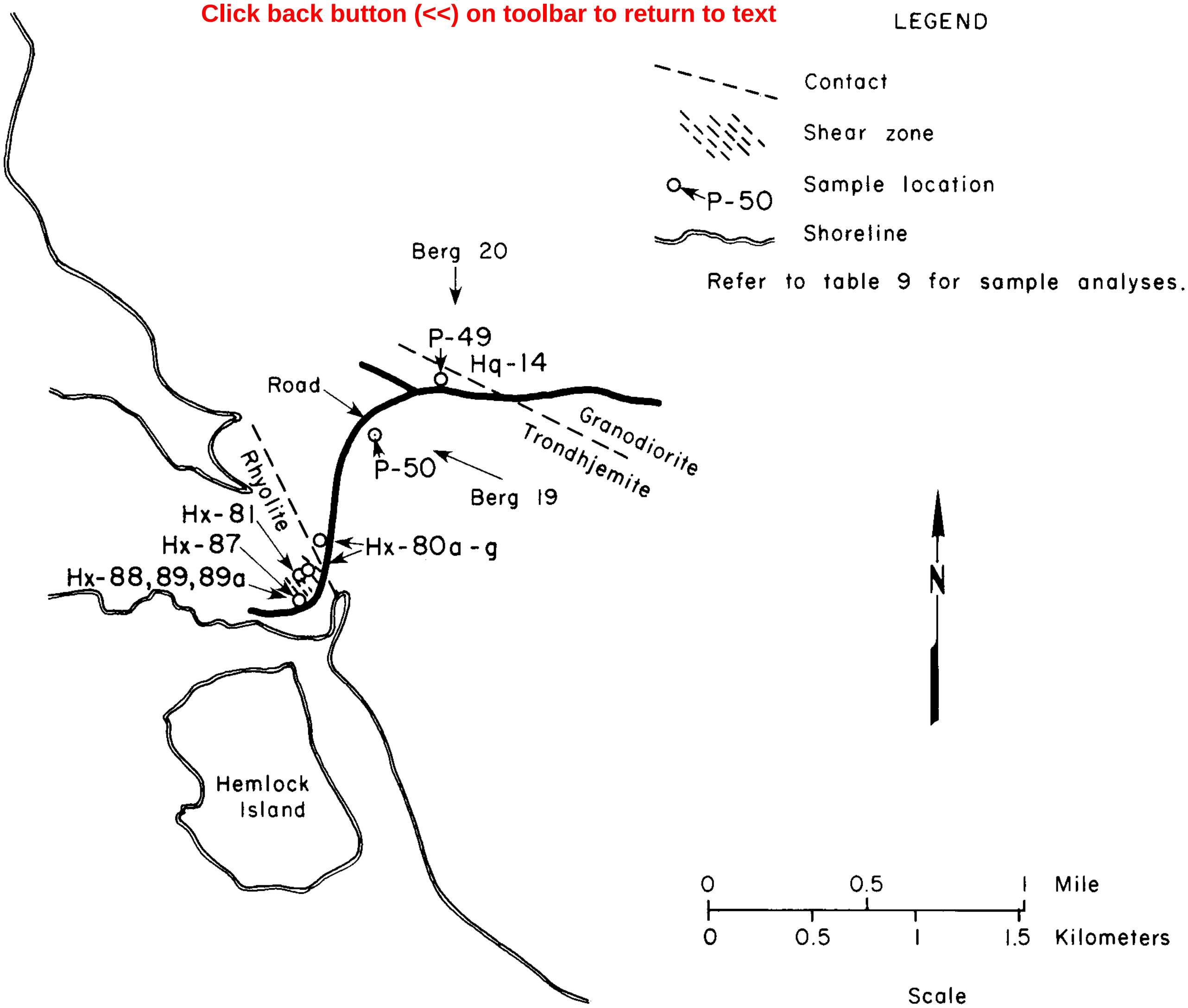

Figure 14. Hemlock Island area, soil and rock samples.

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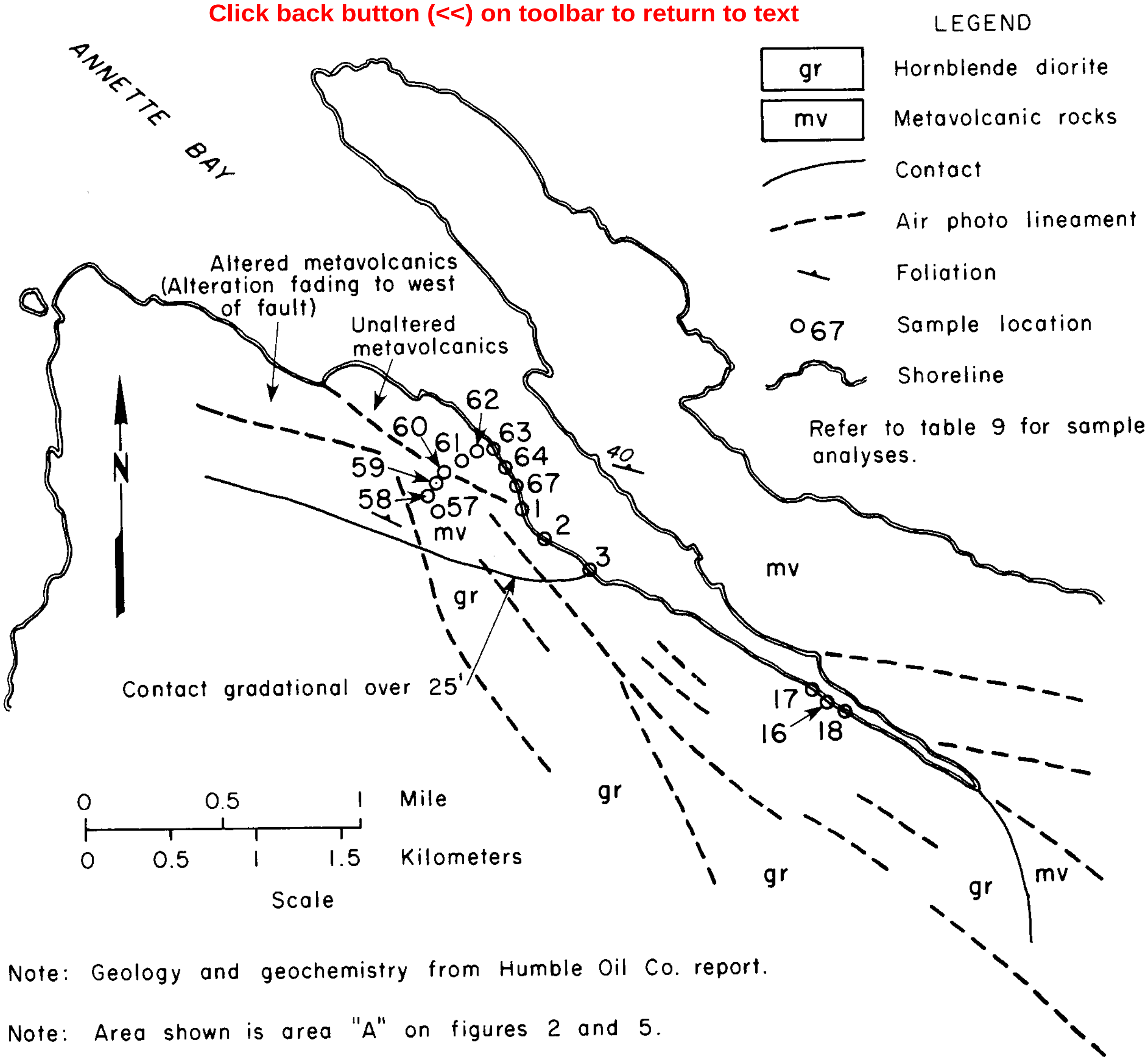

Figure 15. Annette Bay occurrence.